POWER

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Seeing

LONG ago, when I was a stenographer on another paper, I took from the dictation of an old foundryman a series of articles on foundry practice.

They were written in a conversational style, and one of the things that I remember is that he told his helper, "Hold the light so that you can see what I am doing. If you can see the work I can see it myself."

Numerous occasions and occurrences have brought that remark back to me.

And late occurrences have impressed me with the importance of seeing, of looking into things, of knowing how matters stand with the thing upon which one is working.

One man will go blindly at a thing. It does not go the way he wants it to. He yanks and pulls and pries and fumes and perhaps breaks something, whereas if he had intelligently looked it over he would have seen the thing that was making all the trouble and done the job with half the exertion and much less time.

In the case of trouble with an engine or pump or some instrument or apparatus around the plant, one man will commence to putter and experiment, trying one thing after another without sequence or result.

Another will hold the light on the thing and take an intelligent look at it. If he does not know how it is made and how it functions, he will find out. He will deduce that if such a part were out of order the machine would act so and so under a given test or conditions. And by intelligent diagnosis and observation he will run down the trouble.

One does not observe altogether with one's eyes. You know the old observation about the man who could go through the woods without seeing any trees. The eyes may see, but it takes a little brain effort to know what one is seeing and what it means, and what to look for when one is trying to do something.

And it is he who sees in this way who gets things done.

F. R. Low

Cheap Power in Combined Steam and Oil Engine Plant

A Kilowatt-Hour for 10,032 B.T.U. Yearly Average at Doubleday, Page & Co.'s Plant—Output of Steam Engines Balanced with Heating Demand—Diesel Engines Carry Major Part of Load

DOUBLEDAY, PAGE & CO. have demonstrated at their Garden City printing establishment how, with the proper machinery installed and intelligently operated, power can be generated cheaper than it can be purchased.

The possibilities of the factory power plant where steam heating is needed along with power for machine drives, has always been a live topic. Against the combined-service isolated plant has been raised the argument that the power load and the heating load never coincide. As a result, during the summer the steam engines, in operating at a low efficiency, throw away the savings made during the winter heating season.

When the Doubleday-Page plant was built in 1910, the initial equipment consisted of three steam engines, two of which were direct connected to 400-kw. 250-volt d.c. generators, while the third was direct connected to a 50-kw. generator. The boilers were three 72-in. by 18-ft. units, of the horizontal-tubular type. This plant supplies both power and steam heating.

By 1913 growth of the book plant called for an enlargement of the generating equipment, and it was deemed advisable to install a 100-hp. type FH oil engine direct connected to a 60-kw. d.c. generator. In 1923 a further increase in the plant capacity was made by the installation of a 440-hp. type VE air-injection Diesel direct connected to a 300-kw. generator. The FH engine made use of a hot bulb for ignition and was modified into a solid-injection engine by installing a new combustion chamber and fuel-injection apparatus.

In the operation of this plant Chief Engineer Black controls the load on the various units so that the exhaust steam from the steam units is just sufficient to supply the heat needed in the factory buildings. The remainder of the load is carried by the 440-hp. and by the 100-hp. oil engines. During the winter months about half the load is on the steam engines; during the spring and fall the proportion of the load handled by the oil engines increases, and as soon as the heating load drops to zero the oil engines assume the entire load. Since hot water is needed all the year, it is necessary to maintain boiler pressure even though but a small amount of steam be needed.

The heat balance obtained by this combined steam-oil engine plant is 50 per cent better than that obtained in the latest type of superpower station. The B.t.u. per kilowatt-hour for the year October, 1923, to October, 1924, was 10,032, corresponding to 0.528 lb. of oil per kilowatt-hour.

The advantage obtained by the combination of oil engines and steam equipment is vividly portrayed by the table showing the total power-plant costs. The life of the equipment has been taken as 15 years, which is conservative in view of the fact that the steam units are in excellent condition although 15 years old, while the 100-hp. oil engine is 12 years old. Interest is taken at 7 per cent, making the total overhead 11 per cent. The total cost with the 440-hp. Diesel is 2.28c. per kilowatt-hour, while with the 100-hp. oil engine it is 3.35c., this increase being due to the small yearly output of the latter unit.

Oil Chargeable to Power Small

The duty of the boilers is primarily that of supplying heat to the buildings. Passing the steam through the engines permits power to be generated at a low cost, since with the existing water rate of the engines and the efficiency of the boilers, but 0.9125 lb. of boiler oil is required to supply the heat needed to generate a kilowatt-hour in the steam engines. The portion of the oil chargeable to generation in the steam engine is only $1,122.30. Labor is prorated among the oil engines, the steam engines and the heating system. The cost per kilowatt-hour, including the overhead, averages 1.9c. for the entire year, and the cost of the steam-engine output is 1.25c. per kilowatt-hour.

The installation of the oil engines has proved economical to a marked degree. If the steam plant carries the entire load, additional units would be required, making the capital investment approximately equal to that of the combined plant. To generate the 865,000 kw.-hr. now produced by the oil engines, would require over $16,000 for fuel oil, or an excess of $12,000 over present fuel costs. The savings of the present system amount to a yearly profit of 20 per cent on the oil-engine investment.

As has been indicated, the steam boilers must be kept under steam during the summer. It is the plan to install waste-heat boilers in the oil-engine exhaust lines. Part of the jacket water will be passed through these heaters and then put into the house hot-water system. This will permit the shutdown of the boilers for about three months each year. The operation of this plant points a way whereby industrials may obtain an astonishingly high economy from their power plants if the proper machines are installed and if the same degree of intelligence is used in the power plant as in the other departments.

YEARLY OPERATING COSTS

Unit	Kw.-Hr. Output	Fuel Oil Gal.	Fuel Oil Cost	Water Gal.	Water Cost	Waste and Supplies	Labor	Lub. Oil	Overhead Charges	Total Cost	Cost per Kw.-Hr.
Nordberg Diesel	745,000	69,372	$3,825.46	8,050,000	$241.50	$131.00	$5,987	$1,060.00	$5,720	$16,964.96	$0.0228
De La Vergne Diesel	120,000	16,000	880.00	127,000	38.31	28.60	960	135.15	1,980	4,022.06	0.0335
Steam engines	737,000	322,446	1,122.30	2,750,000	825.00	60.60	5,928	147.00	1,220	9,302.90	0.0125*
Heating		252,554	12,627.70				6,438		1,320	20,485.70	.....
Total power and heat	1,602,000	360,372	$18,455.46	10,927,000	$1,104.81	$221.20	$19,313	$1,342.15	$10,240	$50,775.62	$0.019

*If the heating is not charged for its costs as tabulated, the steam engine's cost per kilowatt-hour becomes $0.0403.

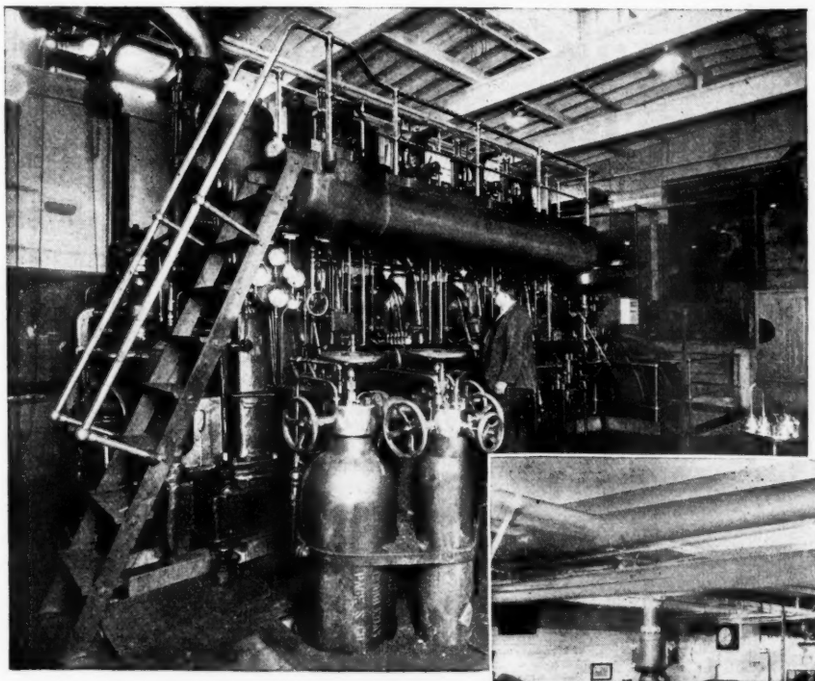


Fig. 1—(Left) Nordberg 440-horsepower Diesel carries non-heating load

Fig. 2—(Below) American-Ball steam engines exhaust into heating mains

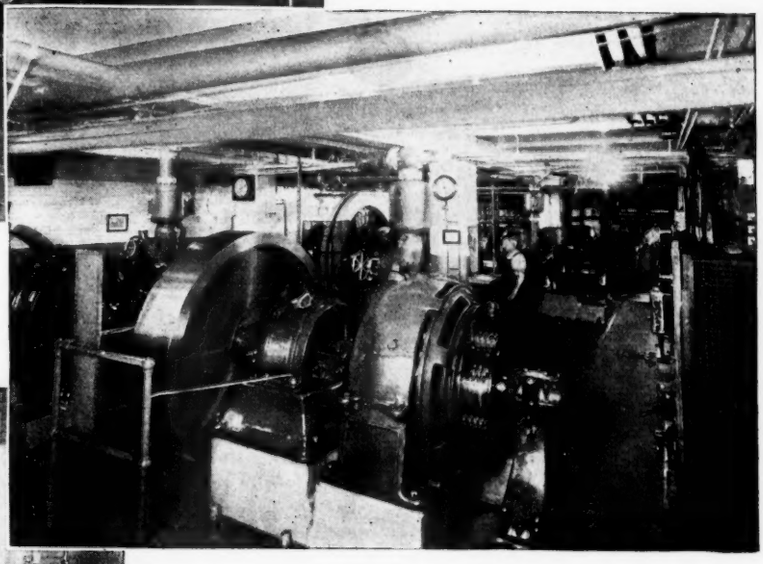


Fig. 3—(Below) Boilers are oil-fired, the Hammel oil-handling equipment being at right of boilers

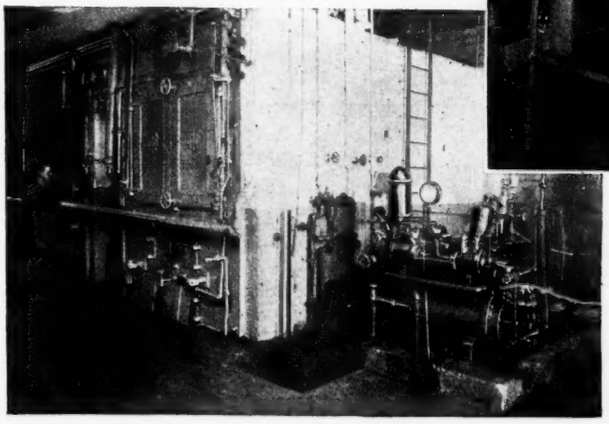
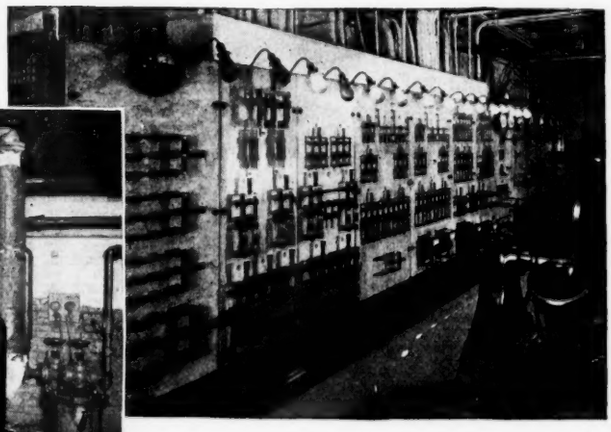


Fig. 4—(Below) Switchboard has feeder panels for each department and integrating wattmeters



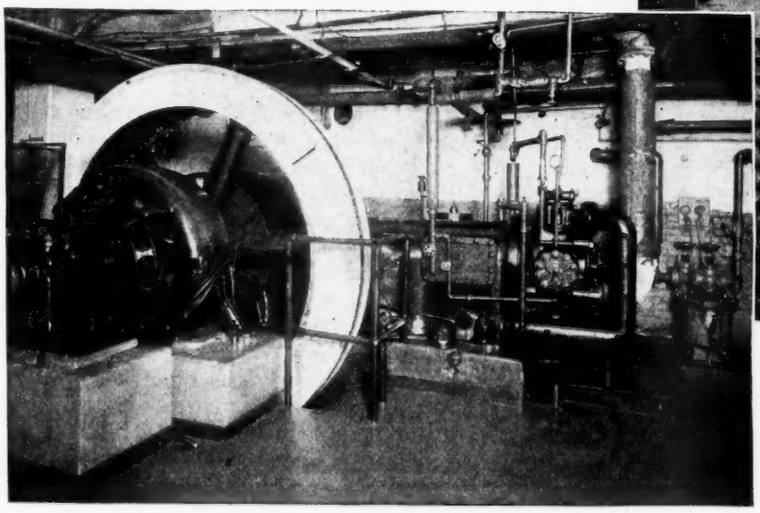


Fig. 5—(Left) One-hundred horsepower De La Vergne oil engine is run in summer

Furnace Designs for Coal and Wood Refuse

By C. M. GARLAND*

FURNACES for moist or dry fuels in which the throat is restricted just enough to insure satisfactory ignition. Mixing of the gases is effected by throat contraction and nozzles properly directed, which discharge preferably the products of combustion.

IN A previous article[1] factors to be considered in furnace design were discussed, and in the present contribution these principles are applied in certain definite furnace designs for the burning of coal or wood refuse.

Fig. 1 illustrates the design of a furnace for a traveling grate under a horizontal water-tube boiler for an exceptionally low-grade fuel with high moisture content. It will be noticed that the ignition arch is long and the bridge wall extends forward so that the amount of radiant heat absorbed by the boiler is that passing through the throat *A*. The heat radiated along the line 1 of the figure which is normal to the face of the bridge wall *B*, is reflected back upon the surface of the grate; the heat radiated from some point along the line 2 is reflected back to the grate surface along the line 3, while the heat radiated from some point along the line 4 is reflected along the line 5.

A furnace of this design would be necessary only in the use of extremely poor fuel, but it will reduce in a large measure the losses through stratification. The ignition arch *C* is low on the grate and extends forward

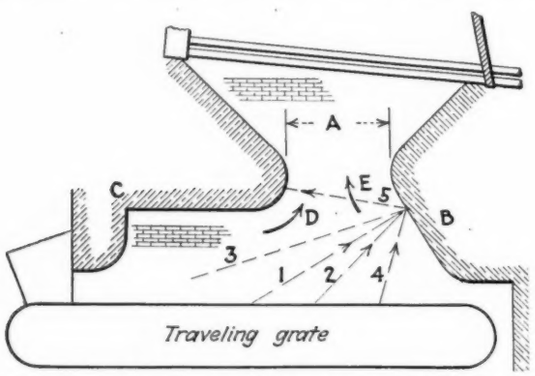


Fig. 1—Chain-grate horizontal-water-tube-boiler design for low-grade fuel high in moisture

so that the products of distillation shoot out from under the arch at a comparatively high velocity in the direction indicated by the arrow *D*. Upon reaching the throat of the furnace these gases meet a volume of gas, rich in oxygen, flowing in the direction of the arrow *E*. The result is that there is a comparatively good mixture of the rich products of distillation with the gases rich in air, and combustion results in the throat of the furnace.

Above the throat the walls are tapered out to allow for the expansion due to the combustion in the throat of the furnace and at the same time to give a large area through the tubes for the passage of the gases. Slowing up the velocity of the gas tends to prevent the formation of slag on the tubes. While it improves the efficiency of combustion, this design of furnace affects both the efficiency and capacity of the boiler

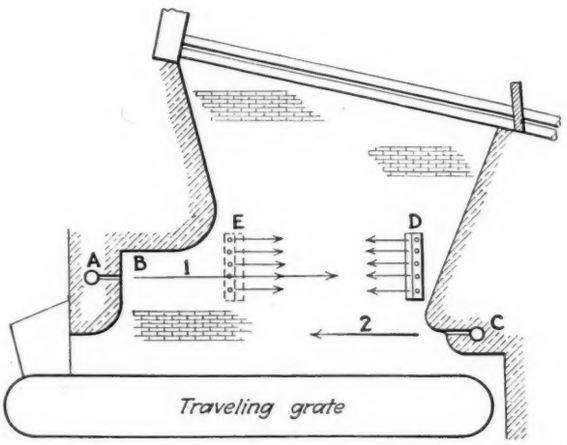


Fig. 2—Same combination for high-grade fuel. The throat is wide, boiler set high and gas nozzles used for mixing

adversely. To obtain a good combined efficiency of boiler furnace and grate, it is necessary to use considerable care in the selection of the boiler. For best results the bottom should be of a design in which the gases are thoroughly broken up in passing across rather than parallel to the tubes.

Heat Absorption Influenced by Direction of Gas Travel and Method of Baffling

It has been the experience of the writer and it can be demonstrated that with a given amount of heating surface, gases passing at right angles to the tubes will lose more heat than gases passing parallel to the tubes. This does not mean that boilers in which the flow of gas is parallel to the tubes cannot be designed efficiently or have not a place in efficient power-plant operation, but it does mean that such boilers must be designed carefully and above all else intelligently installed.

A furnace designed to burn high-grade fuel is shown in Fig. 2. Here a long arch is not necessary to obtain proper ignition and rapid combustion. In this furnace the ignition arch is short, and while the bridge wall extends some distance over the chain grate to offer as much resistance as possible to the leakage of air around

*Consulting Engineer, Chicago.
[1]See *Power*, Feb. 3, 1925.

the grate, yet there is a comparatively wide throat to the furnace, so that the design is one in which the losses from stratification would be large. The gases passing from under the arch would be rich in volatile products, while the gases rising along the bridge wall would be rich in oxygen, and there would be little or no opportunity for these gases to mix. The amount of grate surface exposed to the tube area is large, so that more heat would be radiated to the boiler and the capacity would be greater than could be obtained from the boiler and furnace of Fig. 1.

The life of the furnace shown in Fig. 1 would be comparatively short if fired with the coal adapted to the furnace of Fig. 2. The amount of heat absorbed directly by the surface of the boiler probably would not exceed 10 per cent of the total heat, whereas, in the case of the furnace shown in Fig. 2 the total amount of radiant heat absorbed by the boiler might amount to 40 per cent of the total heat. It is obvious that a furnace of the type shown in Fig. 2 would be well adapted to some form of bent-tube boiler, while the one shown in Fig. 1 would be best adapted to the horizontal water-tube boiler.

Better Mixing Obtained by Discharging Small Streams of Gas from Tuyeres in the Side Walls

Stratification losses in the furnace shown in Fig. 2 would be great, owing to the great width of the furnace throat. To improve the economy of this furnace and reduce the loss due to incomplete combustion, the boiler must be set very high above the grate, from 4 to 8 ft. higher than in the case of Fig. 1 to obtain anything like the same efficiencies in combustion.

To set the boiler at this height above the furnace means a large increase in the cost of boiler setting and

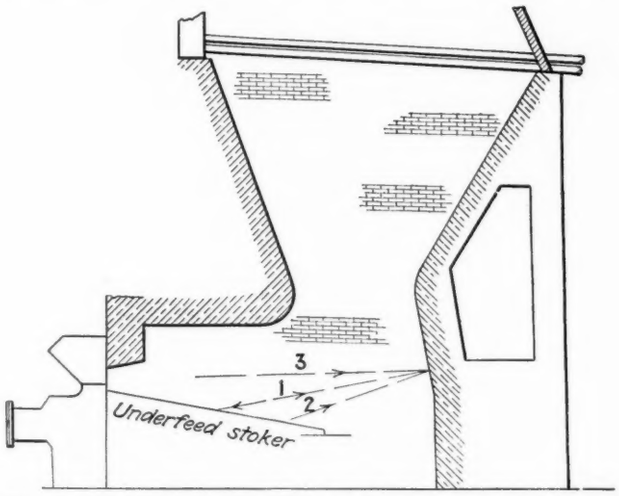


Fig. 3—Furnace for underfeed stoker burning coal high in moisture

a large increase in repair bills. In furnaces of this type the writer would recommend the mixing of the gases by discharging small streams of gas at high velocities from advantageous points in the furnace.

Either air or products of combustion can be used for mixing. Air, owing to the liability of blow-torch action, is less to be preferred. Products of combustion to the extent of about 2 per cent of the total volume would be preferable. These should be drawn off by a suitable fan from some point in the boiler setting where the temperatures do not exceed 1,000 deg. F. and delivered to tuyeres located at proper points in the furnace walls.

In Fig. 2, a gas header *A* is shown at the front end of the furnace adapted to discharge gases along the line 1 into the furnace; this header is provided with a number of outlets or tuyeres *B* about 1 in. in diameter

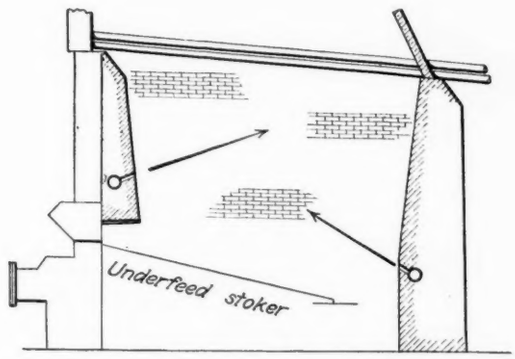


Fig. 4—Underfeed stoker furnace for high ratings and use of low-ignition fuel

spaced about 18 in. apart. It would be desirable to locate a second header in the bridge wall and discharge gases along the line 2. By this means the barrage of products of combustion issuing along the lines 1 would force the rich products of distillation toward the bridge wall, while the barrage of gases issuing along the lines 2 would force the gases rich in oxygen forward and under the products rich in volatile matter, with the result that a much more thorough mixing of the gases would be obtained.

In the event of large settings it might be desirable also to place a row of tuyeres vertically on each side wall of the setting to discharge tangentially as shown at *D* and *E*, the tuyeres shown by the dotted lines at *E* being located in the near wall. By this combination of nozzles and the discharge of the products of combustion into the furnace, the height of the setting could be reduced. As a matter of fact, with these mixing nozzles in operation 6 ft. above the grate would be better than 20 ft. above the grate without the nozzles. The amount of power required for forcing the gas through the nozzles is negligible and the first cost is small.

Design of Furnace for Burning High Moisture Coals on Underfeed Stoker

Fig. 3 illustrates a furnace design for an underfeed stoker using a fuel with high moisture content. This might be considered an extreme design of furnace for a forced-draft type of stoker. In this furnace the losses from stratification would be small, probably in the neighborhood of 2 or 3 per cent, as compared with 10 per cent for a forced-draft chain grate in the furnace of Fig. 2 and 15 to 20 per cent for a natural-draft chain grate with a furnace of the same type.

A furnace design for high ratings and for the use of low-ignition fuel in an underfeed stoker is shown in Fig. 4. In this furnace stratification losses would be high and the boiler must be set at a considerable height above the stoker to offset these losses. By the use of products of combustion for mixing, as indicated in the

sketch, better economy would result and the height of the setting could be reduced. This type of furnace is best adapted to the curved-tube type of boiler.

Furnaces for the Burning of Wood Refuse

Furnaces for the burning of wood refuse must be designed to suit the character of the fuel, and there is a wide variation in this respect. The moisture content may vary all the way from kiln-dried refuse to hog fuel containing up to 60 per cent moisture. Obviously, a furnace designed to meet one extreme would not be satisfactory for meeting the other extreme. In the case of wet hog fuel, every precaution must be taken to maintain the radiant heat within the furnace itself. In addition to this the temperature of the gases leaving the furnace, owing to the large percentage of moisture, will be comparatively low, and this will have an important bearing upon the efficiency of the boiler. The horizontal water-tube type, were it only for the question of heat absorption, would be satisfactory. Unfortunately, however, wood refuse is commonly burned around sawmills and other places where the boiler installation does not receive a great deal of attention. For this reason it might be better to install a curved-tube boiler, which is more easily cleaned.

It is common practice to burn wood refuse in piles on flat grates. I do not believe this to be the most efficient method. While the piles or cones of wood refuse offer a greater area to the furnace heat than if the refuse were spread uniformly on a flat grate, yet the use of the cones tends to promote stratification, in that the great mass of air passes up between the cones and around them. In addition to this the fresh fuel is continuously blanketing the cones and lowering the furnace temperature. The rate of combustion is low,

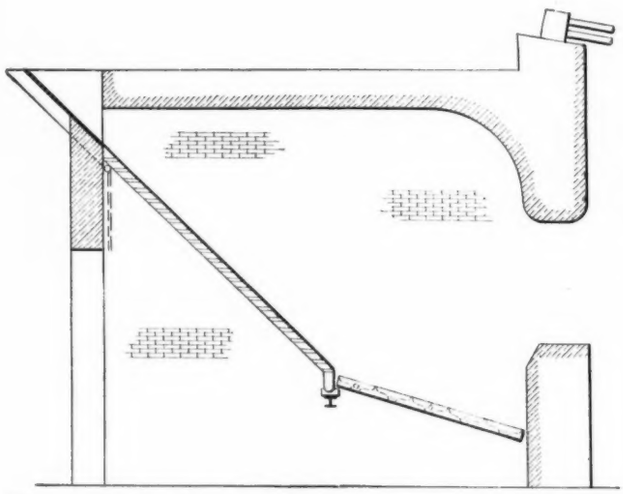


Fig. 5—Inclined grate with large overhanging arch for burning of wet wood refuse

and it is seldom that the boilers can be worked up to their rated capacity without excessive grate areas.

To burn wood refuse, high furnace temperatures are desirable to drive off the moisture and distill the volatile products. The higher the temperature the more rapid the combustion. In fuel with a high moisture content the temperature is the all-important item. Owing to the large moisture content the fire in the bed of wet wood refuse does not tend to strike down as in the case of drier fuel, but remains on the surface. The ignition is always occurring on the surface of the fuel and is due to the furnace temperature distilling off the volatile products in the wood refuse, and these burn at the surface. After the refuse has become charred, then the fire will strike down, and it will burn similar to coal or any other dry fuel.

In place of a flat grate and the burning of the refuse in piles I would recommend the inclined grate shown in Fig. 5. To prevent the material dropping through the grate, which will occur where there is a great deal of sawdust present and at the same time provide a large percentage of air space, a step grate is used. A grate of this type sometimes makes it difficult to distribute the wood refuse, but it is believed that this disadvantage is offset by the better combustion and the higher boiler capacities obtainable. With this arangement the radiant heat from the furnace may

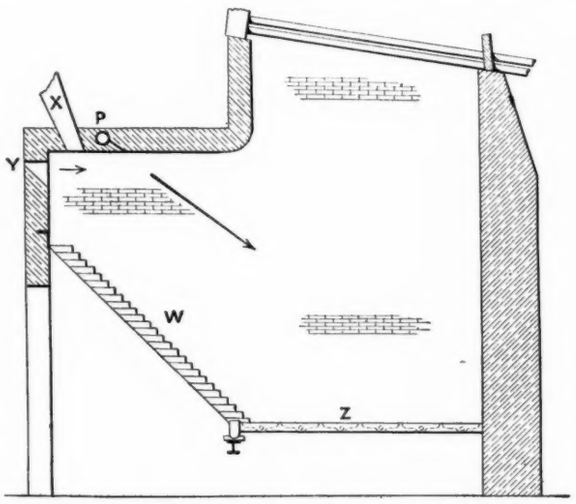


Fig. 6—Furnace designed to burn kiln-dried planing mill refuse with high percentage of fine material

be thrown back to cover the entire grate area; whereas, if the fuel is burned in piles in some form of Dutch oven, such as is always necessary for wet fuel, there always will be a portion of the cones not subjected to the radiant heat from the hottest portion of the fuel bed. The spreading of the fuel in a comparatively uniform layer over the entire grate area means a more uniform distribution of the air and a smaller stratification loss. An inclined grate of the type shown in Fig. 5 will have a trifle greater area than a flat grate to which has been added the area of the surface of the cones.

As shown, the admission of fuel is at one end of the grate and it flows gradually toward the hottest portion of the furnace, so that the moisture is gradually distilled off as the fuel advances. Blanketing is practically eliminated. With this type of furnace I have observed the highest temperatures in the burning of wet wood refuse.

At the end of the 45-deg. inclined grate a dumping or shaking grate is desirable, so that the ash accumulating may be shaken or dumped out from time to time. A damper under the front portion of the grate is desirable when a fuel with a variable moisture content is burned. By placing the damper in the closed position, the upper portion of the grate can be used to dry out fuel.

For the burning of kiln-dried planing-mill refuse,

which usually contains a high percentage of fine material, the furnace shown in Fig. 6 is suggested. The material is discharged through chutes *X* located in the top of the furnace arch, and adjacent to the discharge are openings *Y* in the front wall to admit air. In material of this kind the fine particles "flash" somewhat similar to powdered fuel, so that with the air openings located as previously stated, the fine particles are blown out in the furnace and burned before they pass into the tubes. The heavier material drops onto the step grate *W* from which it gradually flows down to the shaking and dumping grate *Z*.

With this fuel there is more or less difficulty in preventing stratification. To eliminate this and at the same time prevent some of the heavier material being carried by the force of the draft into the tubes, a header pipe *P* is located in the arch and adapted to discharge the products of combustion as previously described along the direction indicated by the arrow. This barrage tends to throw the heavier particles that are not burned back onto the bed of fuel besides thoroughly mixing the air and the products of distillation.

Where kiln dried material is available in which there are no fine particles, a furnace similar to that shown in Fig. 5 should be used, with the exception that the ignition arch should be much shorter, and a much larger portion of the grate exposed to the heating surface of the boiler. With these drier fuels the bent-tube type of boiler will prove satisfactory.

Furnace Lining

The life of the furnace depends not only upon the general lines of the furnace, but also in a large measure on the details of design and construction. Where high capacities are necessary, the best refractories obtainable are none too good, and these refractories should be selected not only from the viewpoint of fusion, but also from that of erosion. The furnace should be "bottled up" no more than is necessary to produce satisfactory ignition. By the use of the flat suspension arch, which has been developed to a high degree of perfection, it is possible to build furnaces to conform to almost any given conditions at a comparatively low expense and at the same time furnaces that will stand up for reasonable periods of time.

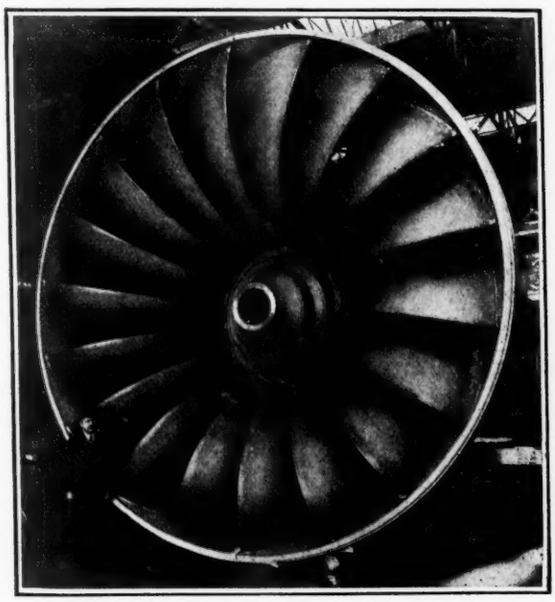
In general, the arches should not exceed 9 in. in thickness and should be arranged so that they are air cooled. The matter of air cooling in the design of the furnace lining is of great importance. It has been observed, in connection with high-temperature furnaces, that thick linings in many cases last no longer than furnaces with much thinner linings. It has been shown that this is due to the insulating property of the linings. The thicker the lining the greater the insulating effect and the higher the temperature on the inside, with the result that the inside melts away rapidly, probably within the course of a few weeks, or until a point is reached where the increased conductivity of the lining lowers the temperature of the inside and stops the fusion.

The same is true in boiler-furnace design. Wherever possible the facing of the bridge wall exposed to the radiant heat from the furnace should not be more than 9 in. thick and should be air cooled. These requirements apply also to the side walls adjacent to the fuel bed. Where forced-draft stokers are in use, this can be effected by drawing a portion of the air through the lining by the fan. In the case of natural-draft stokers the lining can be arranged so that the draft will draw in a certain amount of air. Air-cooled side walls not only prevent the lining melting away, but also tend to discourage the formation of clinkers.

Record Size Hydraulic Turbines

AMONG the important hydraulic turbines in Europe are five now being installed at Chancy-Pougny on the Rhone River near Geneva. Two of the five units were constructed by Escher-Wyss Co., Zurich; the other three were built by Ateliers des Charmilles S. A., Geneva, Switzerland. All five turbine wheels were supplied by the Skoda Steel Works, Pilsen, Czechoslovakia.

The wheel illustrated has an outside diameter of 17 ft. 7 in. and weighs 24 tons. It is made of



Turbine runner 17 ft. 7 in. diameter

two parts and has 18 vanes, and the material in the crown plate and band is of cast steel of about 65,000 lb. tensile strength and 15 per cent elongation. The vanes are of ⅜-in. rolled steel of a tensile strength of 75,000 lb. and an elongation of 20 per cent. They are pressed to shape in dies. Another is 18 ft. 2 in. in diameter, weighs 28½ tons, and has 12 vanes 1 in. thick.

At the plant during 90 to 150 days of the year there is available 14,500 cu.ft. per sec. of water with an average head of 25 ft. The average flow is only two-thirds of this quantity, and the low water measures about one-fifth. The net head normally varies from 24.51 ft. to 26.61 ft., but at high water the head is reduced to 13.2 ft.

With a net head of 24.5 ft. and operating at 83 r.p.m., each turbine develops, normally 7,600 hp. Under these conditions the wheels develop a specific speed of 132 in the foot-pound system. At best gate opening an efficiency of over 90 per cent is expected.

During dry periods the entire water of the River Rhone can be taken by one of these units. These turbines set a record in low-head plants with Francis type runners, in comparison with other units now in operation in Europe and the United States on account of their dimensions, specific speed and discharge.

The Specific Total-Heat of Low-Pressure Steam

By C. HAROLD BERRY, M.M.E.
Technical Engineer of Power Plants, the Detroit Edison Company

THIS article has a two-fold object: first, to show a simple and accurate method for calculating heat quantities for water vapor at low pressure, and second, to discuss the origin and accuracy of a simple formula for the specific total-heat of low-pressure steam; that is, the heat content per pound.

IN CALCULATING the heat carried off by water vapor mixed with the waste gas from boilers or internal-combustion engines, in certain computations in connection with drying or humidifying air, or in any problem involving the constant-pressure heating or cooling of low-pressure steam, the easiest method of computation follows from the fact that the heat that must be added or abstracted equals the difference between the final and the initial specific total-heats of the vapor, in B.t.u. per pound, multiplied by the mass of vapor, in pounds.

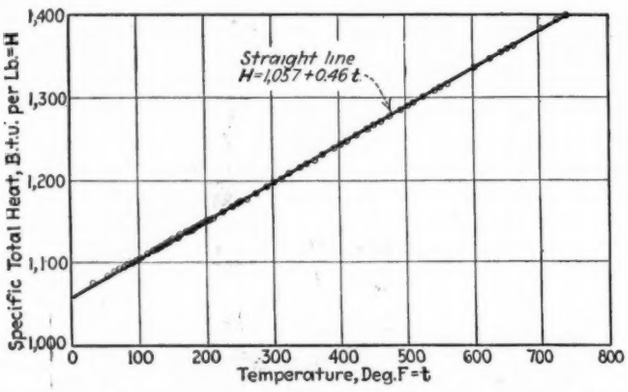


Fig. 1—Comparison of formula with actual steam-table values (Marks and Davis) for superheated steam at various pressures under five pounds

$$Q_{ab} = M(H_b - H_a)$$

To find the value of H, the specific total-heat, from the steam tables, one must know the pressure of the vapor and its quality or temperature. Usually, however, the vapor is mixed with air or flue gas, and its partial pressure is unknown, although its temperature is known, being that of the gas mixture. Fortunately, conditions are usually such that this information is sufficient, for, first, the partial pressure of the vapor is usually low, that is, less than 5 lb. per sq.in. absolute; and second, the vapor is usually superheated, that is, the mixture of gas and vapor is at a temperature well above the dew point, at which condensation would occur. Under these conditions the specific total-heat of steam may be calculated to the nearest single B.t.u. by the formula,

$$H = 1{,}057 + 0.46\ t$$

where H is the specific total-heat in B.t.u. per pound and t is the ordinary Fahrenheit temperature.

For example, a flue-gas mixture leaves the boiler setting at a temperature of 275 deg. How much heat is lost per pound of water vapor which entered the furnace with the air, and with the coal? The initial temperature of air and fuel is taken as 60 deg.

The specific total-heat of vapor leaving the setting, with $t = 275$ deg., is

$$H = 1{,}057 + (0.46 \times 275) = 1{,}184\ B.t.u.\ per\ lb.$$

Notice that this is calculated only to the nearest single B.t.u.

The vapor that entered the furnace (as "humidity") mixed with the air supplied for combustion had an initial specific total-heat, with $t = 60$ deg., of

$$H = 1{,}057 + (0.46 \times 60) = 1{,}085\ B.t.u.\ per\ lb.$$

It is obviously unfair to expect the boiler to condense this water vapor, and therefore the heat lost per pound of such vapor is simply the difference between these two specific total-heats,

$$Q = 1{,}184 - 1{,}085 = 99\ B.t.u.\ per\ lb.$$

This must be equal to 0.46 times the difference between initial and final temperature,

$$Q = 0.46(275 - 60) = 99\ B.t.u.\ per\ lb.$$

to the nearest single B.t.u.

The water vapor that originates with the fuel must be treated differently. Some of this enters the furnace as liquid water. A portion of the heating value of the fuel is used to evaporate such moisture, and to recover this heat the vapor would have to be condensed to liquid at the initial temperature. Another part of the vapor arises from the combustion of hydrogen in the fuel. In the calorimeter, when the heating value of the fuel is determined, this water vapor is actually condensed, and therefore, to secure the full heating value in actual service, it would have to be condensed.

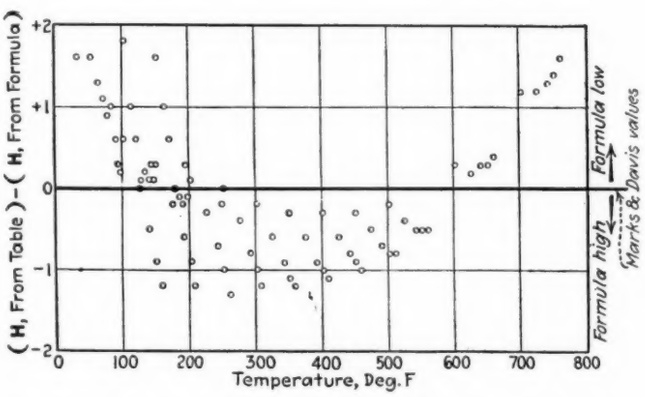


Fig. 2—Variation of steam-table values from formula shown to a large scale

In computing the heat loss due to the escape at high temperature of moisture originating in the fuel, we are simply calculating the difference between the heat

abstracted in the actual furnace and in the calorimeter. In the furnace the moisture is rejected as vapor at 275 deg. In the calorimeter such moisture is condensed to liquid water at the initial temperature, in this case 60 deg. The specific total-heat of liquid water, to the nearest B.t.u., for temperatures up to about 250 deg. is simply $(t - 32)$, and in this numerical example

$$(t - 32) = (60 - 32) = 28 \text{ } B.t.u. \text{ } per \text{ } lb.$$

The heat lost per pound of vapor originating with the fuel is then

$$Q = 1{,}184 - 28 = 1{,}156 \text{ } B.t.u. \text{ } per \text{ } lb.$$

These calculations are easy to carry out, without reference to tables, and are accurate to one B.t.u. per pound, which is entirely sufficient for almost every case.

Discussion of Formula

There is nothing theoretical about the derivation of the formula for the specific-heat of low-pressure superheated steam. It is obtained simply by plotting points from the steam tables and noticing the relation.

In Fig. 1 the specific total-heat of steam is plotted against the temperature. The values were taken from the Marks and Davis tables for superheated steam, for the pressures 1, 2, 3, 4, and 5 lb. per sq.in. absolute, and from the Ellenwood Steam Charts for pressures below 1 lb. per sq.in. Clearly, these points lie very close to the straight line represented by the equation

$$H = 1{,}057 + 0.46\ t$$

A plotting of values from the Goodenough steam tables indicates that a similar relation exists for those values, but the same equation will not hold, since there is a difference of some two B.t.u. between the values given by Goodenough and by Marks and Davis. *Power* has already described the work now being done in the preparation of a new American Standard steam table. This will doubtless necessitate a new formula.

To test the accuracy of this equation, H was computed for the temperature corresponding to each tabular value plotted in Fig. 1. These were subtracted from the corresponding Marks and Davis tabular values, and the resulting differences are plotted in Fig. 2. The heavy horizontal line represents the inclined line of Fig. 1, the points are the same as those of Fig. 1, and the vertical distances from the line to the points have the same meaning in both figures, except that Fig. 2 is drawn to a much larger scale.

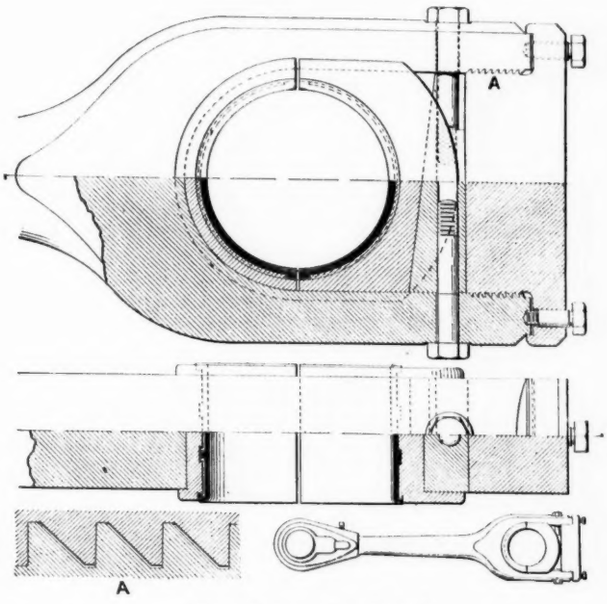
From Fig. 2 it is evident that the formula gives values ranging from 1.3 B.t.u. above to 1.8 B.t.u. below those given by the Marks and Davis tables. Since the value of H is of the order of 1,100, the relative error of the formula is small, and since it is designed for use in cases in which high precision is seldom attainable, it seems wise to employ a simple form of expression which is easy to remember and apply with the slide rule.

It must always be borne in mind that this formula applies only when the partial pressure of the vapor is below 5 lb. absolute, and only when the vapor is saturated or superheated. (The total-heat of wet vapor obviously depends upon the percentage of liquid water which it carries.) Fortunately, flue-gas mixtures always fall within these limits. As an extreme case, if pure hydrogen be burned with the theoretical air supply (no excess), the resulting flue gas will comprise nitrogen and water vapor in the ratio of 3 to 1 by weight; but even in this extreme case the partial pressure of the vapor will be only about 3 lb. absolute.

Connecting Rod for Heavy Service

By Prof. J. Stumpf

Notwithstanding all care taken in the design and manufacture of marine heads, fractures occasionally happen. The bolts are the weak part, whose fracture will entail a partial or complete destruction of the whole engine. The strain in the bolts has been reduced to 3,550 lb. per sq.in., the section of the bolts has been equalized all over the length either by a bore hole or by a reduction of the outside diameter to the bottom of the thread, fine and different threads and the most suitable material have been used, and in spite of all, fractures happen again and again. The bolts of each marine head seem to have a limited number of revolutions before a fracture occurs. Bolts of unsuitable material and shape under heavy strain and day and night work will, of course, soon arrive at such a state of fatigue where a fracture is inevitable. Tough bolts with a constant section over the whole length will stand longer.



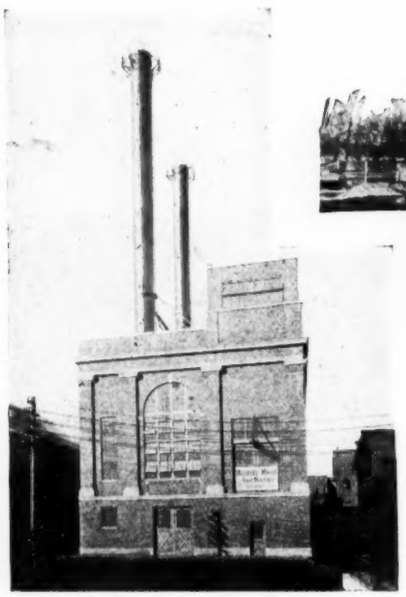
New form of rod end

The usual design of a marine head seems to be fundamentally wrong. First of all the wings extending over the pin are weakened by the bore hole, and instead of using the ample strength of the unweakened wings bolts of very limited strength are used to take up the power.

This state of affairs is radically changed by the head shown in the illustration. The unweakened wings are used as bolts by means of milled threads inside of them.

A block A furnished with milled thread is shifted in place sideways. Thus this block will work like a nut and is kept in place by setscrews preventing the block from shifting sideways. In addition the block embraces both wings from the outside, thus preventing them from bending outward. An adjusting key is inserted between the block and the adjustable part of the bearing and is kept in place by two screws. The thread, of course, is not a real thread but a series of paralleled straight serrations. The heads and locks can be easily milled in one operation.

Below—New boiler plant of New Haven Gas Light Co. burns coke breeze on traveling-grate stokers



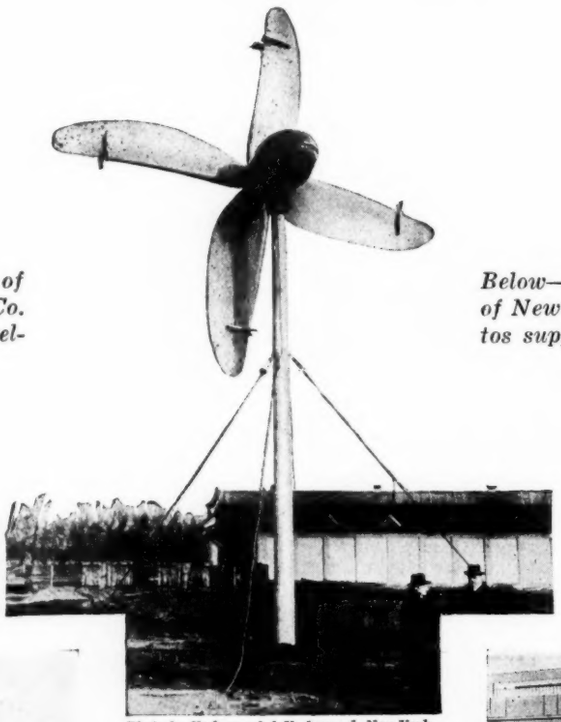
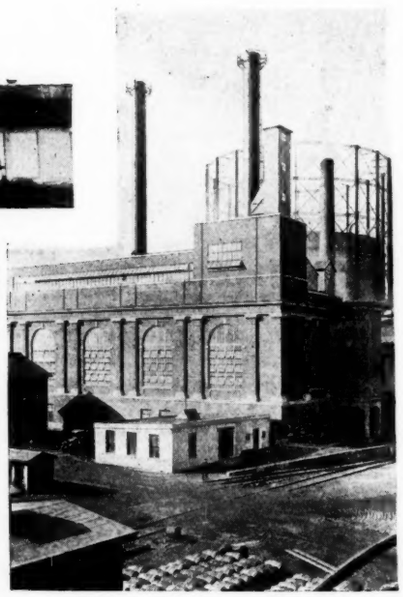


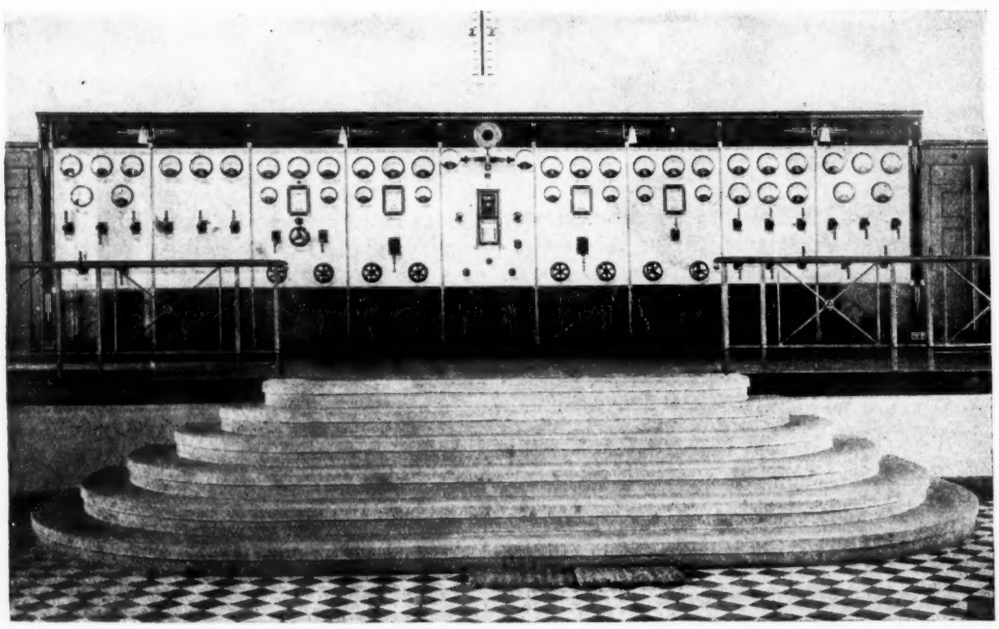
Photo by Underwood & Underwood, New York.

Above—Major Bilau (man on left) and his power-generating windmill

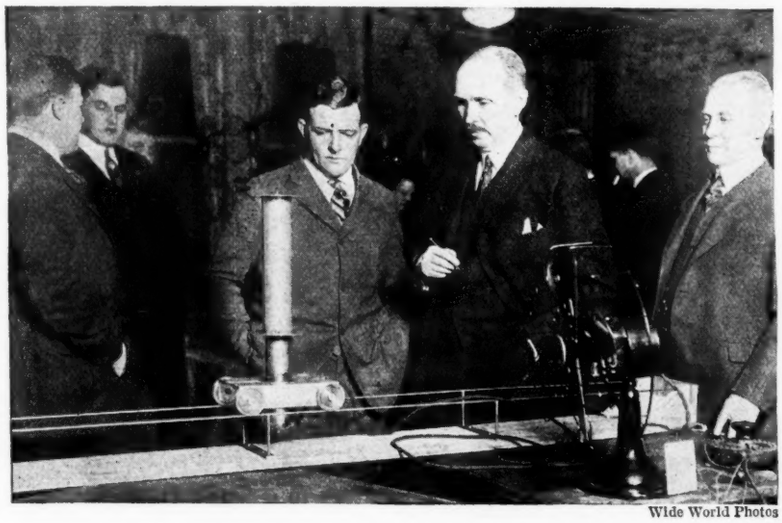
Small fins, centrifugally operated, limit the speed of this German invention. The small size shown generates about 2½ hp. in weatherproof generator.

Below—Another view of boiler plant of New Haven Gas Light Co. Photos supplied by Westcott & Mapes, Engineers





This is not a church altar, but the switchboard of a German hydro-electric plant

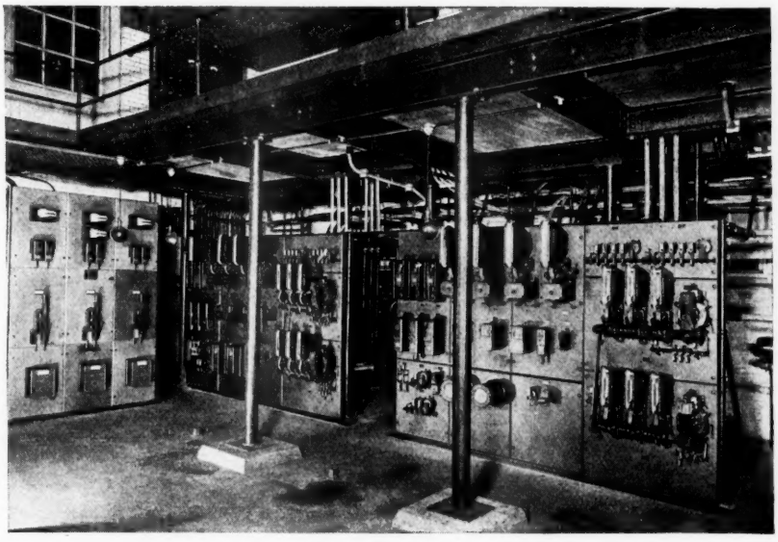


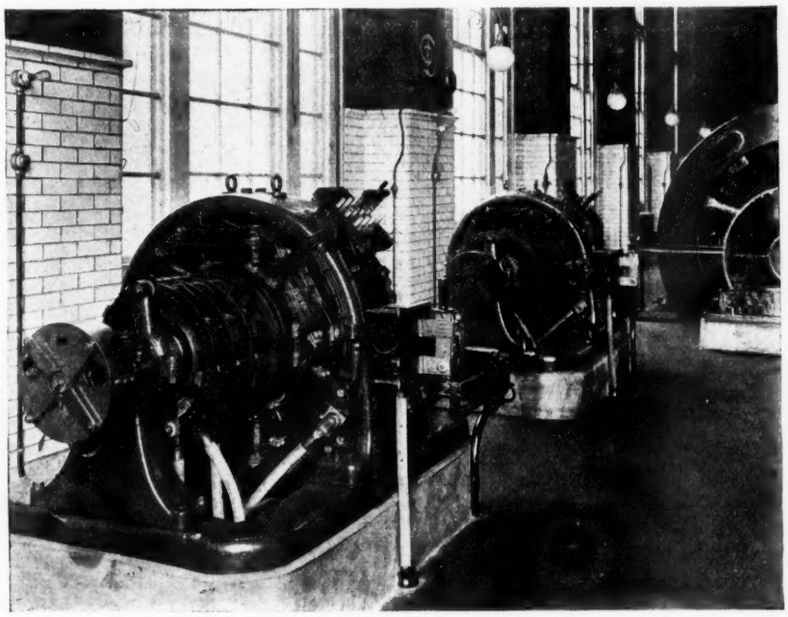
Wide World Photos

Left—Principle of Flettner sailless ship demonstrated at recent meeting of Propeller Club, New York City

When the cylinder on the model truck was spun by a small motor the truck advanced along the track against a fan breeze striking it at an angle of about 30 degrees to the track. The truck wheels were not connected to any source of power, but ran loose on fixed bearings.

While generating the bulk of its power requirements as a byproduct in the production of heating and process steam, the Dennison Manufacturing Co., Framingham, Mass., has installed the two rotary converters shown below for the use of supplementary purchased power during certain periods when such use is economically justified



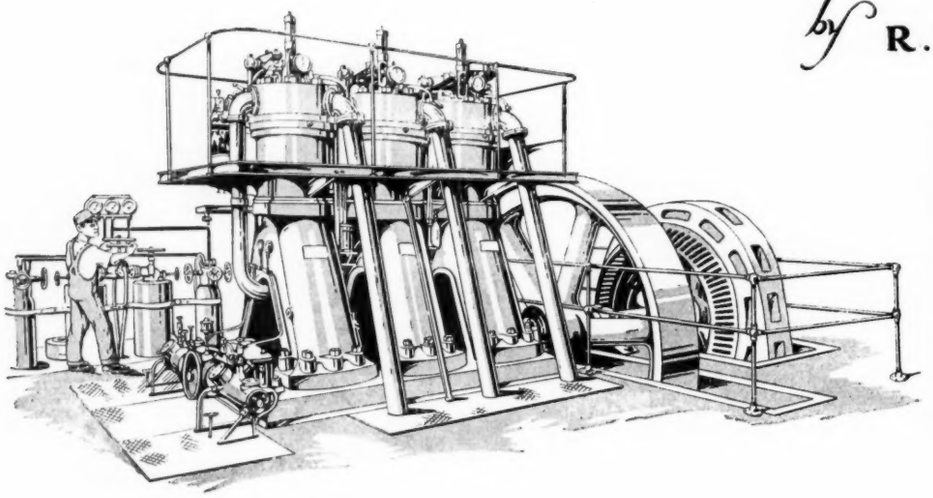


The automatic switchboard (above) for the rotary converters was installed at the Dennison plant, on the floor below the two machines which it controls

Pictures obtained through courtesy of H. F. Scott, mechanical superintendent.

OPERATION OF DIESEL ENGINES

by R. Hildebrand *



How to Buy and Handle Diesel Fuel Oils

THE successful operation of a Diesel engine depends to a great extent upon its combustion. Good combustion, next to effective cooling and proper lubrication of the engine, is one of the three main factors which make the operation of a Diesel engine easy, and the quality of the fuel has a vital influence on the combustion. To clearly understand the importance of supplying a suitable fuel to a Diesel engine, the process of combustion and its influence on the operation of the engine must be understood.

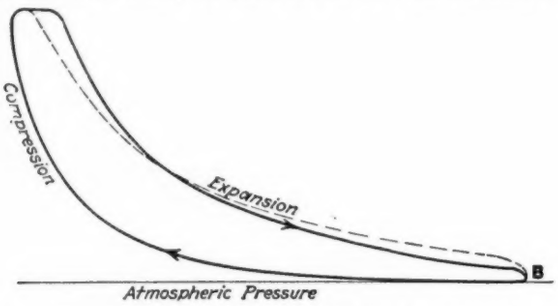


Fig. 1—Faulty combustion revealed by the expansion line

Good combustion means quick burning of the fuel at the beginning of the power stroke, followed by a long expansion indicated by the full line in Fig. 1. Such combustion results not only in a smokeless exhaust, but also in a low pressure at *B* and consequently a low exhaust-gas temperature. With good combustion the lubrication of the power cylinder is easily accomplished because the oil film adhering to the liner is exposed to the fire only at the extreme upper end of the cylinder. It is evident that a rapid drop in pressure and temperature within the power cylinder during the working stroke is beneficial to the engine, particularly to the piston and exhaust valve, as their temperatures will then remain comparatively low.

Poor combustion means a slow burning extending over nearly the whole power stroke, sometimes even into the exhaust stroke, and is indicated by an expansion line similar to that shown dotted in Fig. 1. Such combustion results in a smoky exhaust, a high exhaust pressure and a high exhaust-gas temperature. It is difficult to lubricate a cylinder having poor combustion because the liner is exposed to fire over its entire length, which tends to destroy the oil film. In addition hot pistons and hot exhaust valves may be caused by faulty combustion.

Good combustion can be obtained in all Diesel engines, and the engineer should be satisfied with nothing less than this. Sometimes we may hear the remark that an engine runs better if the combustion line on the card is not level but sloping. This remark is wrong and misleading because just the opposite has been fully demonstrated by experiments. A sloping combustion line indicates slow combustion and afterburning which should be avoided.

It is true that a Diesel engine can burn fuel oil varying greatly in character. However, there are desirable and undesirable grades of fuel oil, and when buying fuel, it is better to select a desirable grade even if it should cost a little more than the poorer one.

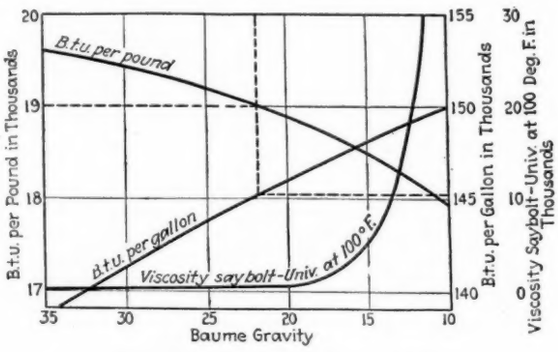


Fig. 2—Fuel-oil characteristics

The fuel oil used in this country at present is generally "topped" crude oil; that is, a crude from which the lighter oils, such as benzine, gasoline and kerosene, have been extracted by distilling. The topped oil coming from the still, if not further blended, is called a straight-run fuel oil. A compounded fuel oil is gen-

*Chief engineer, Diesel Division, Fulton Iron Works Company.

erally made up of heavy residues from the refineries and bottom sediments from the storage tanks blended with lighter oils in order to obtain a fuel with a desired specific gravity. These compounded oils are frequently unsuited for use as Diesel fuels because they show a high residue content when tested.

The following three analyses of fuel oils strikingly show how the residue contents in different oils may vary. The item "residue" refers to that which remains after the fuel has been heated in a closed oven for 120 hours at 575 deg. F. From these analyses it appears that the residue content, as well as the flash and burning points, are not dependent upon the specific gravity nor the degree Baumé, as the latter is similar for all three fuel oils although their residue contents varies from 0.49 to 56.4 per cent.

Analysis	1	2	3
Heat value b.t.u.	19,210	18,680	19,113
Gravity Bé. at 60 deg. F	26.1	28	22.5
Flash point, deg. F.	258	140	384
Burning point, deg. F.	294	164	436
Acid No.	0.14	0.38	0.24
Sulphur, per cent	0.94	0.40	0.68
Water, per cent	0.15	0.08	0.08
Residue at 575 deg. F. (120 hr.)	0.49	32.1	56.4
Ash, per cent	0.04	0.04	0.04

No. 1 fuel gave very satisfactory results, while No. 2 presented some difficulties, and No. 3 could hardly be used at all. This shows that a certain degree Baumé

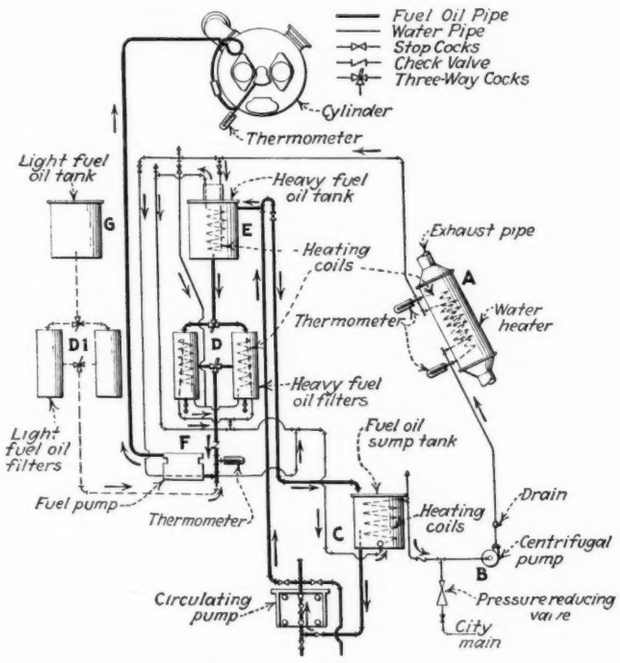


Fig. 3—Apparatus for heating boiler oil

does not definitely indicate whether a fuel oil is suitable for a Diesel engine.

The base of the oil, asphaltum or paraffin, has little bearing on its value as a fuel. Oils of from 20 to 35 deg. Bé. are very desirable as far as fluidity is concerned. It can be seen from Fig. 2 that lighter oils do not contain as many heat units per gallon as do the heavier oils. As the fuel is bought by the gallon and not by the pound or by the heat value, a light oil may not be economical and it may introduce a fire hazard.

Heavy fuel oils, or those of high specific gravity corresponding to a low degree Baumé, flow sluggishly through the pipes and atomizers. It is generally necessary to heat them even during warm weather. Therefore, unless the installation is a large one and especially equipped to handle heavy fuel oils, particularly bunker oil and Mexican crudes, it is desirable to pay the difference and use a lighter and more easily handled oil.

As a guide for buying fuel oil I recommend the following specification, except where the plant is especially well equipped and the engineer feels that he

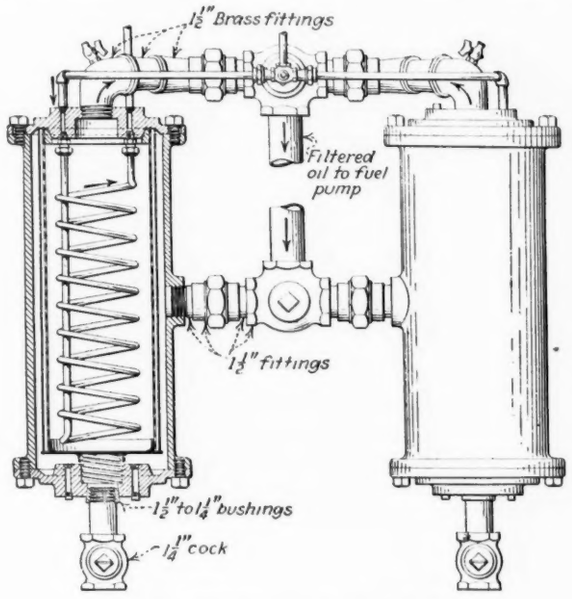


Fig. 4—Heating coils in oil filter

can operate the system successfully with lower grades of fuel than the specification calls for.

Grade, straight-run topped crude.

Gravity, 20 to 30 deg. Baumé at 60 deg. F.

Heating value, 19,000 B.t.u. or higher.

Flash point, between 125 and 250 deg. F.

Burning point, between 160 and 300 deg. F.

Residue, not over 10 per cent after a sample has been heated in a closed oven 120 hours at 575 deg. F.

Sulphur, not over 1.5 per cent.

Water, not over 0.25 to 0.33 per cent.

Ash, not over 0.10 per cent.

Heating of the fuel oil may be accomplished by circulating warm water through coils located in the main supply tank, the overhead fuel service tank, the fuel-oil filter, and in the fuel pump, as shown in Figs. 3 and 4. Wrapping all the fuel pipes with a heat-insulating covering may be necessary; this covering being a cotton tape wrapped twice around the fuel and water pipes and heavily coated with water glass (sodium silicate).

The oil should not enter the pump above a temperature of about 160 to 180 deg. F., depending on the nature of the fuel. Fuel oil heated above these temperatures may give up vapors which would cause the pump to become vapor bound. Instead of heating the fuel oil to an excessively high temperature before it enters the pump, it should be reheated after it has passed the pump and before it enters the fuel-injection valve. These remarks refer to heavy fuels such as bunker oils and Mexican crudes.

The heating of the fuel requires not only special equipment but careful attention. In many cases it does not pay to bother with too-heavy an oil unless the plant is large. As a general rule, no heavier fuels should

be used than those that can be burned with a clear exhaust. The limitation depends more upon the skill and the attention of the engineers and on the equipment for heating the fuel oil than on the design of the engine, although it should not be assumed from this that every engine is adaptable to burning heavy fuels.

Since a heavy oil flows sluggishly through the atomizer of the fuel valve, a high injection-air pressure is necessary. Light fuel oil may be atomized and injected properly by an injection air pressure as low as 700 lb. at full load, while heavier oils require an injection air pressure of 850 or even up to and exceeding 1,100 lb. Heavier fuel also requires an atomizer of less resistance, that is, fewer atomizer plates or a nozzle plate with a larger drilling.

If fuel oil containing a high percentage of sulphur is used, the exhaust piping will corrode unless precautionary steps are taken. The hydrogen in the fuel oil and the oxygen in the air unite to make steam, which forms moisture when the exhaust gases cool below condensing temperature, which occurs when the engine is shut down. This moisture and the sulphur in the form of oxides of sulphur form sulphuric acid, which corrodes the exhaust piping. In order to overcome this bad effect, the fuel should be changed to a light grade a few minutes before the engine is stopped. Generally, it is advisable to start with a lighter grade of fuel and then change over to the heavier one. When using heavy fuel oil, care should be taken that no fuel mixes with the lubricating oil.

Other Impurities May Affect the Engine Chemically

Besides sulphur there may be in the fuel oil other impurities that chemically affect the engine. There may be acid or dissolved minerals, which have a corrosive effect on the fuel pump, fuel needles and their seats. Fuel oil of this nature causes leaking and sticking of the needles in their guide bushings. Cast-iron needles generally resist corrosion better than steel ones. Tobin bronze or Monel metal may, in some instances, be better than cast iron. It is best to avoid fuel oils that have a corrosive effect on the needles or at least equip the engine with needles not affected by the fuel used. This will obviate frequent difficulties with the parts that come in contact with the fuel oil.

Fuel oil frequently contains a considerable amount of water which must be removed before the fuel reaches the engine. There are records that engines would not start or that their operation was irregular because of water in the fuel, and it is advisable to provide a water trap in the fuel pipe from which the water may be drained.

Fuel oil frequently contains dirt and grit, which should be removed before it reaches the engine. If dirt and grit are allowed to enter the fuel pump, the pump plunger will wear excessively, causing the stuffing boxes to leak. The fuel-pump valves will not hold tight and will require frequent grinding if the fuel is gritty. The fuel-injection valves are affected likewise if mechanical impurities are contained in the fuel. Wear of the needles and their seats results in bad combustion, smoky exhaust and even preignition. The needles will wear their guide bushings and the fuel oil passage and the atomizer plates may clog up.

All these disturbances may be conveniently and cheaply prevented by passing the fuel through a filter before it reaches the engine. Such a filter, if properly taken care of, will soon pay for itself, as it will materially help to keep the engine in good running order.

Fig. 5 shows a fuel-oil filter of the twin type. The oil passes first through a wire screen and then through a thick layer of filtering felt.

The water and dirt should be drained from the bottom of the main storage tank to prevent it from entering the fuel line leading to the engines. It is desirable that the fuel supply pipe should not be connected to the extreme bottom of the oil tank, but a few inches above, in order to avoid drawing into the pipe any sediment that may have accumulated in the tank. The main storage tank should be cleaned occasionally. When doing so, precautionary measures should be taken to avoid explosions or asphyxiation, as there may be gases remaining in the tank after it is drained for cleaning. Therefore, before entering the tank, allow it to remain open for several hours and permit no naked flames to come near the openings.

[This is the fifth of a series on oil engine operation. Others appeared Jan. 20, Feb. 3, Feb. 17 and March 3.—Editor.]

Smokeless Combustion

The combustion space should be at least in a good red heat so as to insure burning all the combustible into carbon dioxide and water, which would give smokeless operation. Although about 14 lb. of air is required to burn one pound of soft coal completely, only half this amount should be admitted through the grate. The remainder should be supplied over the fuel bed. If this can be well preheated, smokeless combustion is practically assured.

Leaving the door open a short interval after feeding fresh coal supplies an extra quantity of this secondary air when most needed. Poor draft always causes smoke and lowered efficiency. Ample combustion space, involving high settings on boilers, is required with such fuels as Indiana bituminous, pulverized coal or oil.

There are two general ways of firing bituminous coal. One is to place a thick bed of coal on the front grates. Here it will coke and the gases given off will pass over incandescent fuel and be consumed, the coked fuel then being pushed over the remaining grate area. This is well adapted to return tubular boilers.

The second method is that of spreading the new coal evenly over the grate in small quantities at a time through alternate doors. One-half of the fuel bed is kept incandescent. A uniform size of coal, neither coarse nor fine, gives best results. High-volatile coals require a bed of four to six inches, and those with less volatile somewhat thicker beds, as outlined in the January, 1925, issue of *Rose Technic*.

It is a fact that unannealed hard drawn tubes tend to become corroded more readily than tubes that have been annealed. The limiting factors governing the degree to which condenser tubes may be softened or annealed are practical considerations such as the correct degree of hardness of the tube to withstand the strain of packing in the tube sheet without deformation, to withstand the knocks of ordinary handling and shipping without abrasion and to prevent the sagging of the tubes between supports when installed in the condenser shell. As a result of these considerations tubes are usually given a special low-temperature anneal.

Connecting Two Alternators to the Same Waterwheel

By N. L. REA
Construction Engineer, General Electric Company

A NUMBER of methods are described for connecting two alternating-current generators to the same prime mover and have them in correct phase relation.

CONNECTING two alternators to the same prime mover and to the same bus is a problem that occasionally arises in construction work. There are, of course, as many ways of doing the job as there are of skinning the proverbial cat, so you shouldn't be disturbed if your pet scheme is not included. The problem is to connect two alternators of the same number of poles together mechanically so that they are in exact step electrically. We will assume the machines are duplicates electrically and mechanically, as this is usually the case and greatly simplifies the problem. Also assume the two machines are the same distance from the wheel. If the latter is not the case, the twist in the longer shaft may be enough to prevent coupling the machines together so that they will operate under the usual changes of load. It is possible to get a setting for any given load, but the twist in the longer shaft at other loads may be sufficient to prevent satisfactory operation at other loads.

Aligning with Steel Wire

One machine should have special drilling in the coupling. One half the coupling can have all the holes drilled. The other half should have two holes only. These should be diametrically opposite each other and should be slotted along the bolt circle three or four times the diameter of the bolts. This gives a chance to use temporary bolts until the final setting has been obtained. The rest of the holes can then be drilled, using the other half of the coupling as a jig and the bolts fitted.

If there is clearance and no walls to interfere, stretch a steel wire over the waterwheel and the two generators. From this wire drop plumb bobs at the outer ends of the generator shafts and set the steel wire by means of these plumb bobs directly over the center line of the two machines. It is, of course, assumed that both generators have been aligned and leveled with the waterwheel and one generator permanently coupled to the wheel, our problem being simply to couple the second machine to the wheel so the two machines will run together and properly divide the load.

If the machines are duplicates, mark the rotor rim to show the center of the poles over or nearest to the rotor hub keyway. If they are not alike, take the poles that are connected to corresponding collector rings. The field cables should be traced back to make sure the collector rings are connected to the same side of the exciter busses. Two similar poles are wanted, both north or both south to line up. Fig. 1 shows a typical arrangement with the tight line stretched over the outfit. Plumb bobs are hung as near the end of the generator fields and the matched poles of each generator aligned to the plumb bobs. The two bobs at either end are used to sight on the mark on the field rims and to set them both over to the plumb bobs.

Other Methods of Aligning Generators

There may be cases where a tight line cannot be stretched over the whole outfit. A short section of line can be set over each generator and the corresponding poles set to the lines. There are several other methods of getting the two generators in the same relative position.

Temporary coupling bolts can be put in and the machine started for a trial. Assume that the machines are dry and ready for service. The first thing is to check the phase rotation of the two machines. This had best be done at the switchboard or the busses so that all cable connections will be checked at the same time. A small induction motor that can be connected in turn to each will do very nicely. A phase-rotation testing outfit may be used or, failing these, a lamp bank or potential transformers and lamps, depending on the voltage, may be used. Fig. 2 shows this arrangement. If possible use carbon filament lamps in testing phase rotation or in synchronizing. The modern high-efficiency lamps are too hot for the filament to go entirely "dark."

If the machines have the same phase rotation and are in synchronism, cut in all the field resistance and open the field switches on both machines, connect their

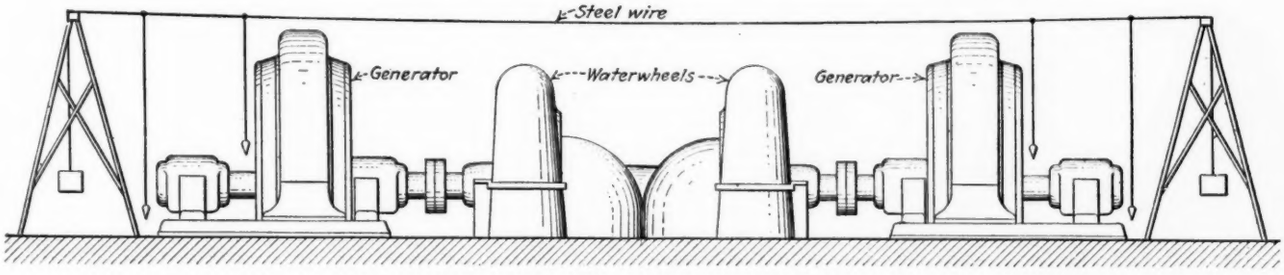


Fig. 1—One method of lining up the rotors of two alternators to the same waterwheel

armature circuits together and then throw the smallest possible field current on both machines simultaneously. If there is an appreciable cross-current between them with the low field strength, shut down, mark the two halves of the adjustable coupling and move them slightly against each other. Try again for cross-currents. If they are smaller, you are going in the right direction. If larger, you are, of course, headed the wrong way. It's an easy matter to get the point that will give the smallest cross-currents.

The same results can be obtained by measuring the voltage between corresponding phases of the two machines, as in Fig. 3 and setting the adjustable coupling to give the lowest voltage. After the best setting has been obtained, the remaining holes can be drilled and the coupling bolts fitted.

A Quick Aligning Job

In one case this problem was put up to an erector who was long on practical experience and short on theory. Time pressed and he worked out the following scheme: A framework was knocked together alongside the open coupling, all bolts being removed. This framework was topped by a board parallel to the shaft and with the edge of the board about over the center line of the shaft. Fig. 4 shows the arrangement. He then made a light, thin-bladed cold chisel. The blade was wider than the gap between the halves of the open coupling.

The next step was to connect the machines together, apply field to both machines and start the waterwheel.

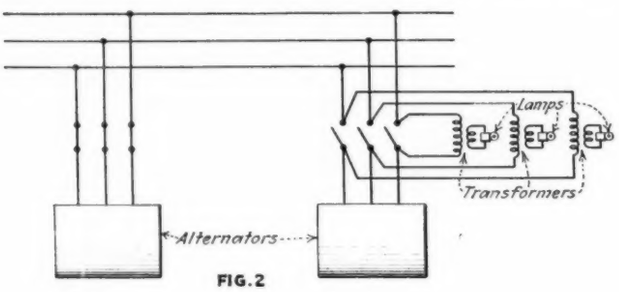


FIG. 2

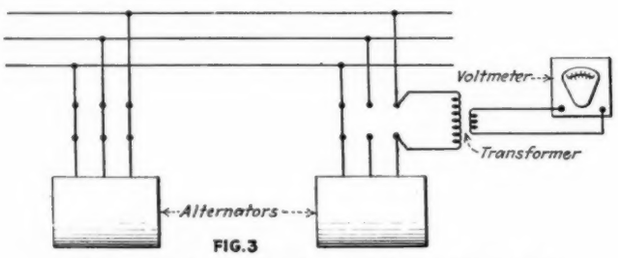


FIG. 3

Figs. 2 and 3—Phasing out two alternators

The disconnected machines came up to speed as a synchronous motor. The erector then took the cold chisel in his finger tips and slid it down alongside the plank until it just cleared the revolving coupling and was over the open joint, the blade of the chisel being parallel to the center line of the shaft. He then made sure there was no one in line and hit the chisel a sharp blow. The chisel took a trip, but there was no harm in that.

On shutting down there was a good mark on both halves of the coupling. These marks were brought together, the coupling bolts fitted, and the machines divided the load very nicely with this setting.

If there is need of fine adjustments after the couplings are made up, the shims under the stator feet can be shifted from one side to the other, thus slightly rotating the armature. This movement can be doubled by shifting shims on both machines so as to rotate the stator in opposite directions.

Satisfactory operation under these conditions is possible only if the machines have similar characteristics.

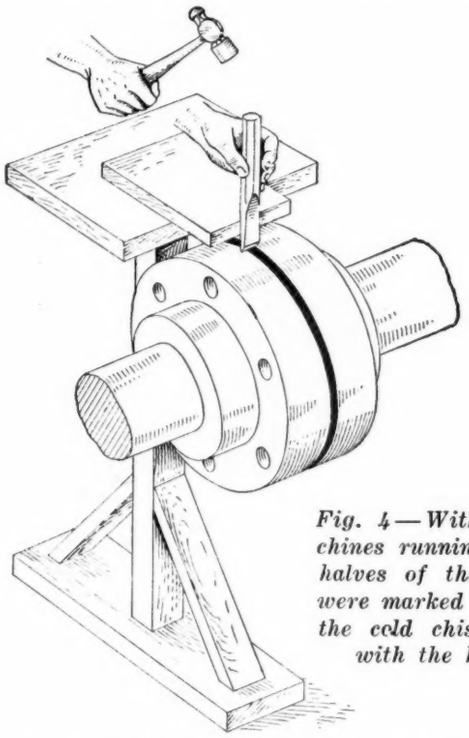


Fig. 4—With the machines running the two halves of the coupling were marked by hitting the cold chisel a blow with the hammer

If the regulation or change of phase angle as the load comes on is decidedly different on the two machines, it may be difficult if not impossible to get satisfactory division of load over the whole range. It is possible to get a setting for any particular load, but the difference of phase angle at light loads may be enough to cause heavy cross-currents.

Long Shaft Caused Trouble

The trouble is not always electrical. Some time ago two duplicate machines were connected to the same waterwheel and a complaint made that they did not divide the load. Investigation showed one generator close to the waterwheel and the other nearly five times farther away at the end of a long light shaft. The twist in this long shaft was enough to amount to about seventy electrical degrees at full load. Dropping the load would probably be disastrous under these conditions. It was impossible to get these machines connected together to operate satisfactorily or safely with the great difference in the length of their shafts. The only thing possible was to move the far generator to the wheel and cut out the long run of shafting. The twist in this long shaft under full load was about an inch on a 25-in. coupling.

On page 286 of the Feb. 24 issue, Fig. 1, a straight non-condensing turbine was inadvertently shown instead of a small bleeder turbine as called for in the caption.

Method for Determining the Leaving Loss of a Steam Turbine

By B. C. SPRAGUE*

Leaving loss and limiting vacuum were described by the author in the Dec. 16, 1924, issue. Their practical calculation is herein given. Over-all plant efficiency requires the most economical vacuum. This in turn depends largely on the amount of leaving loss, representing the unused energy due to the speed of the steam leaving the last row of blades. Steam economy at a given load is improved by raising the vacuum up to a point called the limiting vacuum. Beyond this higher vacuum results in increased steam consumption.

THE absolute speed of the steam leaving the last row of moving blades in a turbine can be computed when the pressure and volume of steam flowing at this point are known. The leaving angle of the last row of blades in a turbine is usually so designed that with rated vacuum the direction of discharge of the steam leaving the last row of blades will be practically parallel to the shaft at the most economical load. At other loads, however, and with other than the rated vacuum the direction of the discharge steam will vary from the axial and the absolute leaving velocity will be greater than the axial velocity, as shown in Fig. 1.

On a turbine as at *A*, Fig. 1, with a leaving blade angle of 40 deg. and a blade speed of 500 ft. per sec., we will assume that the steam will leave the last row of blades in an axial direction when the absolute leaving velocity as measured from a stationary point

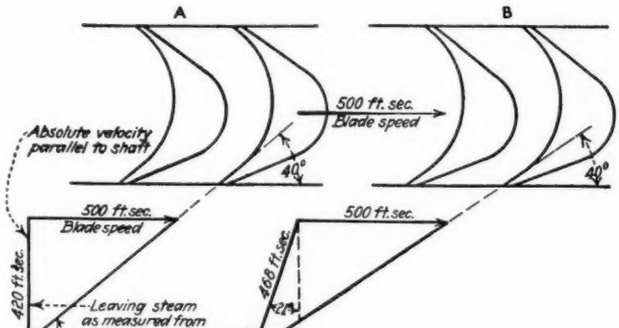


Fig. 1—Increasing the exhaust steam volume changes the actual speed and angle of discharged steam

is 420 ft. per sec. If the volume of steam discharged is increased by one-half, the steam will then leave the last row of moving blades at an angle of 21 deg. from the axial direction, as at *B*. The absolute leaving speed will in this case be 48 ft. per sec. greater than the axial velocity of the leaving steam at *A*.

*Efficiency department, West Penn Power Co.

Because of the difficulty of taking into consideration the variation of the angle of discharge of the steam leaving the last row of blades, the actual leaving velocity has been assumed in this discussion to be the same as the axial velocity. The error resulting from this assumption will not be great except with

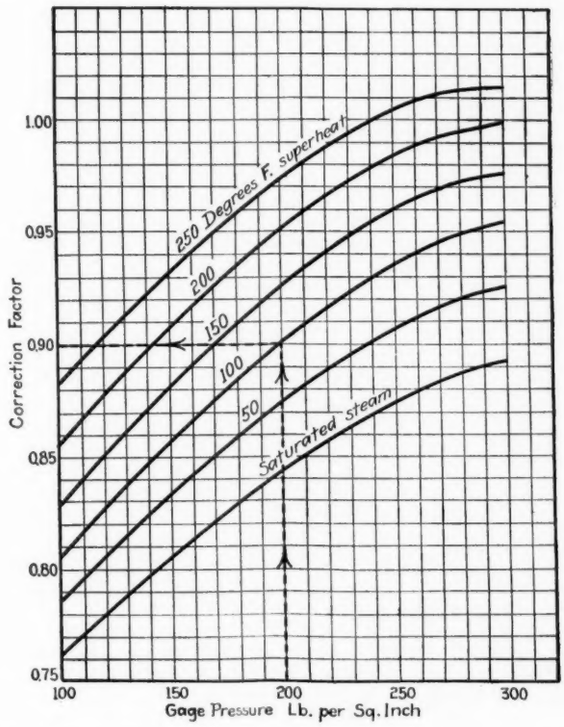


Fig. 2—Correction factors for steam conditions other than 300 lb. gage, 200 deg. F. superheat

extreme conditions of load and vacuum. In working out the vacuum correction for any specific turbine in which the angle of the last row of moving blades is known, the actual leaving velocities can be calculated and used if greater accuracy is desired.

The leaving area at the last row of blades of a turbine is given by the formula

$$A = C\pi(d - L)L$$

when A is the leaving area in square feet, d the external diameter of the last row of moving blades in feet, L the length of the last row of moving blades in feet, and C a factor which may be taken as 0.95.

As explained in Part I, since the leaving loss varies as the square of the actual leaving steam speed, it is small at low velocities and becomes appreciable only when the leaving velocity is high. With low leaving speeds, the gain in economy due to increased vacuum is nearly as great as it would be in an ideal turbine. With large leaving velocity, however, a better vacuum means less relative gain.

When the limiting vacuum is reached, the rate of increase of the leaving losses with increase in vacuum balances the tendency to thus improve economy. If the vacuum is raised beyond the limiting point, a decrease in the turbine economy will result. Fig. 3 shows the per cent reduction in steam consumption per one-tenth inch increase in vacuum for turbines having initial steam conditions of 300 lb. gage and 200 deg. F. superheat for various loads and blade areas. The values of the vacuum correction in Fig. 3, although true only for the initial steam conditions stated, can be used for all high-pressure turbines when great accuracy is not needed. In case greater accuracy is desired, the values taken from this figure should be divided by the correction factors obtained from the curves in Fig. 2.

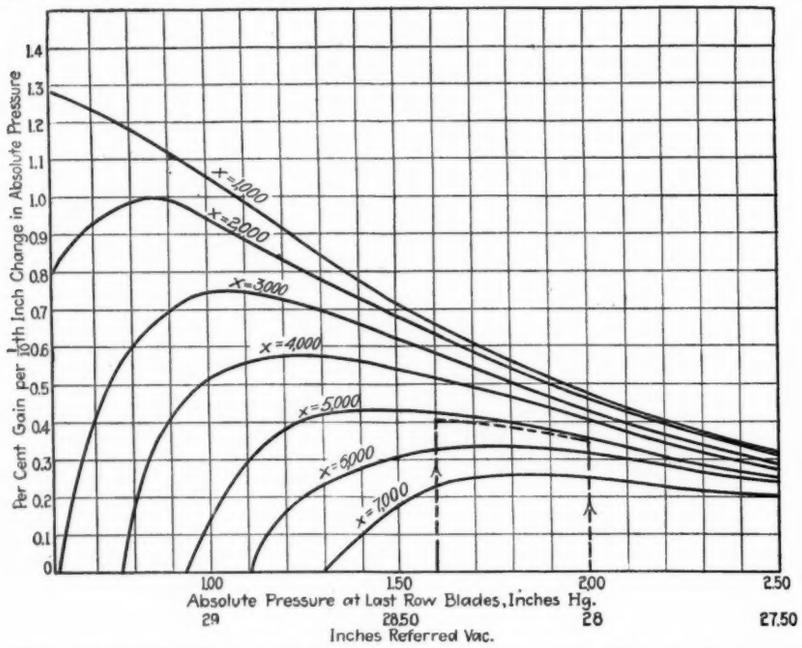


Fig. 3—One-tenth per cent change in water rate due to increased vacuum shown by each square in dotted area

Plotted for various values of X in the formula $X = \frac{Wq}{a}$ where W is the steam flow, lb. per hr.; q is quality of steam at exhaust, per cent dryness, and a is the effective leaning area, is square feet. Initial conditions 300 lb. gage, 200 deg. F. superheat.

In an effort to make the curves as general as possible, those in Fig. 3 are drawn for various values of the quantity $\frac{Wq}{A}$, in which W is the hourly steam consumption, pounds per kilowatt-hour, of the turbine at the load at which it is desired to know the vacuum correction; A is the effective leaving area, square feet, and q is the quality of the steam leaving the last row of blades in per cent dryness. The curves in Fig. 4 give approximately the quality of the exhaust steam for various initial steam conditions.

With any given value of $\frac{Wq}{A}$ the increase in economy resulting from any increase in vacuum will be given by the area in Fig. 3 between the curves for the values of $\frac{Wq}{A}$ corresponding to the load on the turbine and the zero line of the figure, and limited on the sides by the lines representing the values of the vacuum before and after the change. The area of each square in Fig. 3 represents a gain of one-tenth per cent.

As an example, suppose it is desired to know what change in the steam consumption will result from increasing the vacuum on a turbine supplied with steam at 200 lb. gage and 100 deg. superheat. Assume that the turbine has a leaving area of 50 sq.ft. and that it is desired to know the per cent change in steam consumption that results from increasing the vacuum from 28 in. to 28.4, referred to 30-in. barometer, when the turbine is using 300,000 lb. of steam per hour in the region of greatest economy, with a water rate of 12 lb. per kw.-hr. Referring to Fig. 4, the quality of the steam is found to be approximately 0.869.

$$\frac{Wq}{A} = \frac{300{,}000 \times 0.869}{50} = 5{,}214$$

The area inclosed by the dotted line in Fig. 3 represents a gain of 1.5 per cent. If accuracy is desired, the gain shown by the curves in Fig. 3 should be divided by the factor given in Fig. 2, which for the assumed initial steam conditions, will be 0.90. This gives 1.67 per cent as the reduction in steam consumption resulting from an increase in vacuum from 28.0 to 28.4 in. The limiting vacuum will be 29.05 in., where the curve for 5,214 crosses the zero line. Fig. 3.

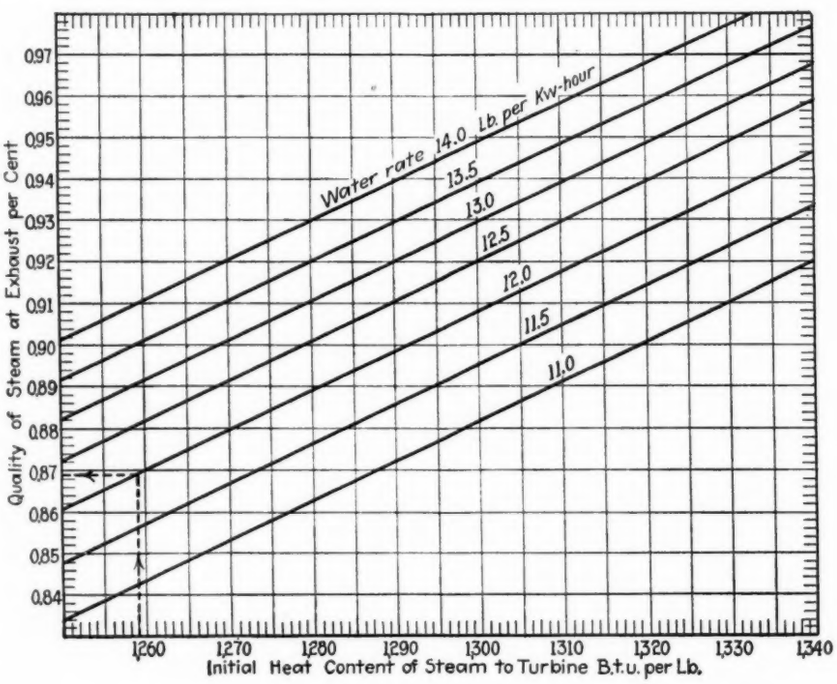


Fig. 4—Quality of exhausted steam at 29-in. referred vacuum

Combination Steam and Oil Engine Plants

THE necessity of steam heating during the winter is taken by many as proof that cheap power is obtainable in the isolated plant by using the engine's exhaust for heating. Unfortunately, the heating and power demands seldom coincide, and since the available exhaust steam is sometimes greater than needed for heating, the efficiency of the factory plant is below what it would be if the two demands were co-ordinated. A further disadvantage is that the non-condensing operation in summer involves a high cost per kilowatt-hour for the power generated and offsets the winter economy.

An attractive solution of this problem was made in Doubleday, Page & Company's printing plant. Steam engines are loaded to a point where the exhaust steam just meets the heating system's demands. The Diesel engines carry all above this amount. The arrangement gives a very high efficiency, never less than around thirty per cent when the oil engines are carrying all the load, to over fifty per cent when the heating system and the steam engines are in operation. The yearly average heat consumption per kilowatt-hour, giving credit to the exhaust-heat utilization, is approximately ten thousand British units, thirty per cent under the best central-station practice. While such a combination will not always prove economical, in many plants the increased overhead charges are quickly absorbed by the savings in operation.

Steam-Table Suggestions

IN THE issue of March 10, M. H. Sabine, of Birmingham, England, made a number of suggestions that should be of value to those entrusted with the task of formulating the results of the steam research now in progress at the Bureau of Standards, Massachusetts Institute of Technology and Harvard.

Being satisfied that the utmost pains will be taken to insure the accuracy of the results, which is of course the primary consideration, engineers will naturally turn their attention to the matter of presenting the results in a form employing to the limit all devices that will save time and nerves in the routine use of steam tables and diagrams. The correspondent on the other side of the ocean is just as interested in this matter as are American engineers, because he expects to use the new steam tables as a tool in his work. On the principle that forethought is better than hindthought, it is to be hoped that his suggestions will receive careful consideration by the makers and users of steam tables.

Few will object to his request for a "one-story" book comprising steam tables, heat-drop tables and large heat-entropy diagrams. As to conventional signs and definitions standardized on common-sense lines, a start has already been made, and it should not be difficult to secure the adoption of national standards. International agreement on such subjects is greatly to be desired, but more difficult of attainment.

The inclusion of all data up to the critical point, as suggested, would involve some guessing but might be warranted if the probable error in the higher ranges were posted to warn the unwary user.

The substitution of graduated steps of total temperature for similar steps of superheat would be in line with the logical tendency now in evidence among power-plant men.

Mr. Sabine's division of all steam into four catagories, "wet," "dry," "superheated" and "undercooled," is ideally simple and appeals strongly to common sense. Of course superheated steam is also dry steam, but custom could easily restrict the use of the term "dry steam" to what is now called "dry saturated steam."

Not all readers may be so largely in agreement with Mr. Sabine. In any case other brief comments will be of interest.

Detailed Piping Layouts No Longer Necessary

PAINSTAKING accuracy in detailing piping is often the means by which economy of manufacture and installation is assured. Where appreciable complications exist as for instance the piping for stage bleeding, drains, condensate, etc., under a large turbine, the layout is increasingly difficult and the avoidance of mistakes in design as well as in manufacture or erection becomes a more acute problem. In fact, some readjustment when assembling, and perhaps shipment of piping to the manufacturer for change is not by any means infrequent. Expense and delay may thus be introduced to an undesirable extent.

Pipe alignment is such an important requisite and yet the absolute avoidance of mistakes sometimes so difficult, that the effort involved in piping design may be one of considerable magnitude as compared with other power-plant problems. The Gordian knot has been cut in some instances by eliminating accurate detailing through the application of gas or electric welding. Joints, bends, correction of alignment, interferences of solid members and other factors can then be taken care of in the field with a minimum of checking, planning and general worry. In fact, the avoidance of delay, the utilization of what would otherwise be wasted material and the permanent tightness of such joints point to a new era in station pipe work resulting from a more extended use of welding.

A large number of operating men have not accepted welded joints. There is no recognized practical test for measuring the degree of strength and margin of safety, while the variable quality of a welder's work appears as a menace to reliability. Welding, however, has proved satisfactory in some instances after many

years of application for steam pressures around two hundred pounds. Plants are operating where line-welded joints largely replace bolted ones. It seems possible to secure the desired reliability by taking the necessary precautions. The advantages of this method have proved so far-reaching as to make a serious effort to depart from bolted flanges well worth while.

Machine Efficiency vs. Plant Efficiency

FORTUNATELY for our fuel supply, high efficiency and economy in power plants are closely related. If this were not true, the great improvements that have been made in steam power-plant design to reduce the heat units per unit of power output, would probably never have occurred. In the final analysis every power-plant operator is interested in the economical production of power—that is, producing it at the lowest cost per kilowatt-hour at the switchboard—and not in saving fuel, except so far as this saving reduces the cost of power generation.

Probably there has never been a power plant designed in which the fuel rate could not be reduced by installing main units of higher efficiency or using additional auxiliary apparatus. On account of not being able to justify the highest efficiency design on an economical basis, a lower efficiency plant was built, although one that would produce power at the lowest cost consistent with reliability and other service considerations.

As long as the boiler and the power generating sections of the plant were operated very largely as independent units, the evaporation per pound of coal burned under the boilers and the water rate of the prime movers were a fairly good index to the operation of the plant. With the introduction of bleeding the main unit at a number of points for feed-water heating, reheating between stages, driving the auxiliary load from the main generator or an auxiliary generator and other innovations in the modern station, the various functions of the plant have become so interconnected as to make the efficiency of individual apparatus have a somewhat intangible meaning.

If a steam turbine is operated as a straight condensing unit, the boiler and turbine performances are a fairly good index to station efficiency. Bleeding the turbine at a number of points to heat the feed water may increase its water rate, but will result in a higher over-all efficiency for the station. This is due to taking some of the low-head heat that would be thrown away in the condensing water, back into the boiler and converting it into high-head heat that can be utilized in the turbine.

Driving the plant auxiliaries by steam engines or turbines and heating the feed water with the exhaust will show a high efficiency so far as driving these units is concerned. If electric motors are used for these drives with power taken from the main unit, it will result in an improvement in the over-all station economy, over using steam-driven auxiliaries, where feed-water heating is done with low-pressure steam taken from the main turbines, even though the water rate of these machines may be increased. So it is through the modern station; it is not alone a case of selecting units of high efficiency, but also of co-ordinating all the equipment in the plant into a machine that will produce a kilowatt-hour with the lowest number of heat units consistent with a minimum cost.

The Oil Engine Needs Research Work

IT MUST be confessed that the designer of the steam engine and turbine has a far better knowledge of the action going on within the machine than has the designer of the internal-combustion engine. Possible blade speeds, steam velocity and like problems have been solved in a more or less satisfactory fashion. On the other hand, the oil-engine designer is, in a way, groping in the dark.

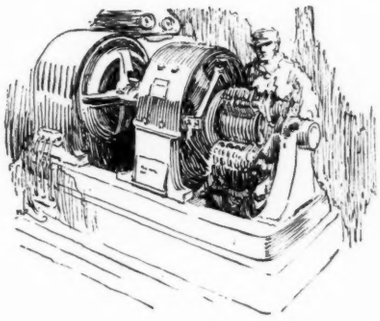
Actual development has reached the point where experimental operation of injection apparatus is obtainable for a two-stroke-cycle oil engine running at two thousand and for a four-stroke-cycle engine running at four thousand revolutions per minute. But what is going on inside the cylinders? Mechanical ingenuity is far ahead of the physicist. The engineer knows what he can do mechanically, but he knows but meagerly the possibilities and limitations of the liquid fuels he is using in the engine. For example, in the high-speed injection engine he is, perhaps, expecting too much regarding the rate of fuel vaporization. What scientific evidence has he that he is not attempting to operate engines faster than the fuel can vaporize?

What if the steam turbine were supplied with water sprayed onto heated entrance faces of the nozzles. How long would it be before a steam engineer would want to know if all this water had time to vaporize before called upon to react on the turbine blades? We know we cannot, for a given initial pressure and temperature, hasten the conversion of the steam's heat into jet velocity within the nozzle. What is the limit to the rate at which the individual molecules of the water can be accelerated among themselves in vaporizing? The steam engineer does not need to know because he can have vaporization occur in the boiler without having to have it keep in exact step with the revolutions of the engine.

Not so with the solid-injection oil engine. Has the fuel in a high-speed solid-injection engine time to vaporize before called upon to burn and create pressure on the pistons? Granting that the liquid fuel under these conditions first cracks, can the carbon then freed burn in time to give good efficiency at two thousand cycles, and much less, per minute? To what extent is the heat economy in an engine better when the fuel is first vaporized instead of immediately cracking into hydrogen and free carbon? This knowledge would be for general use and benefit. Is it not time that our college laboratories were set upon such findings and vigorously supported? They have among them a variety of talent that a government bureau cannot attract and command; hence, in that respect they are the more favorably endowed for initiating original research. German schools do it. Can ours?

Every engineer who makes combustion computations should get some meat out of the article by C. Harold Berry, on page 410. It boils down to this: The total heat per pound of water vapor as found in air and in flue gases may be computed, within one B.t.u., by the formula $H = 1{,}057 + 0.46t$, where t is the Fahrenheit temperature. This formula at once frees the computer from all need for tables so far as computing moisture losses is concerned, while at the same time insuring a degree of accuracy fully sufficient for all practical purposes.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for February will be announced next month.

Power is pleased to announce the awards of the judges for the first and second prize contributions received during January for this department in accordance with the terms of the contest as stated above.

The first prize of $25 goes to Joseph Jacobs, of Columbus, Ga., for his contribution entitled, "Inserting Bedplate Under Motor in Limited Time," which appeared in the Feb. 17 issue.

The second prize of $15 goes to B. C. Weaver, of Napa, Calif., for his contribution entitled "How to Save Money in the Refrigerating Plant." This also appeared in the Feb. 17 issue.

The judges were: (Chairman) Norman N. King, chief engineer, Singer Bldg., New York City; Willis Lawrence, mechanical engineer, Interborough Rapid Transit Co., New York City, and D. L. Fagnan, formerly refrigerating engineer and more recently associated with the Smoot Engineering Corp., New York City.

Why the Boiler Gages Showed Different Pressures

The following conditions were observed in a small boiler room. The installation consisted of one 3,000-sq.ft. and one 4,000-sq.ft. boiler. The larger boiler was equipped with superheaters, and the smaller one delivered steam to the same header without superheating. From one end of the header steam was delivered to two turbines, and from the opposite end of the header process steam for the factory was drawn. The pressure gage for each boiler was connected to the steam drum of the boiler on which it was mounted and the pop valves were set at 155 pounds.

When both boilers were operating, the recording gage on the header would show 125 lb., the gage on the small boiler 130 lb., and the gage on the large boiler 145 lb. The discrepancy in the readings of the three gages led the boiler inspector to test them all very carefully, but a comparison with a master gage at various pressures showed them to be very nearly correct.

When the gages were replaced after testing, the same differential in pressures was noted. This was explained by the fact that where there is a flow of steam through a line, it is caused by a difference in pressure, the steam always going from the higher to the lower pressure. The pressure in the main steam drum of the large boiler was actually 145 lb., but there was a 15-lb. drop through the superheater, which reduced the pressure to 130 lb., the same as that of the small boiler. The drop from 130 to 125 lb., as shown by the recording gages, was due to friction loss and pressure differential, as it was connected to the header a short distance from the boilers.

H. M. TOOMBS.

Chicago, Ill.

Device for Checking Integrators on the Old Style G. E. Flow Meters

Any engineer who has had to calibrate the integrator on the old style General Electric flow meter knows how difficult and at the same time how important it is to maintain a slow and uniform rotation of the chart. This particular type of integrator is no longer manufactured, but there are, no doubt, many readers of *Power* who have them installed and will use them for some time to come. For the benefit of such readers here is a simple device that will do the trick.

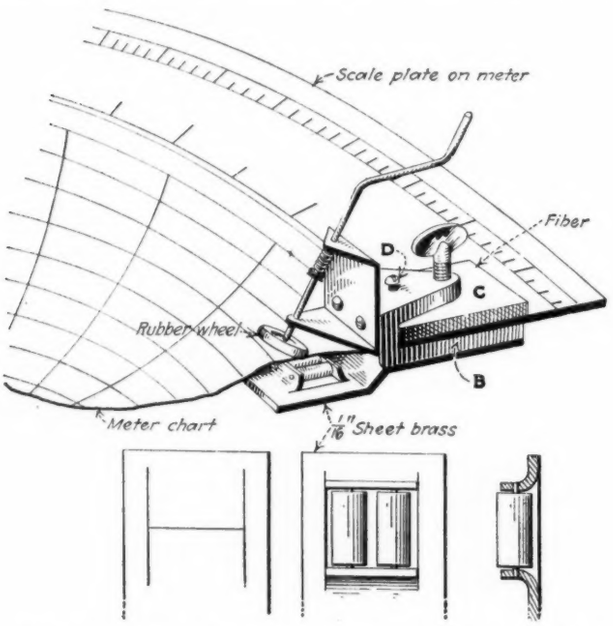
It consists of a rubber-tired wheel, such as are sold for radio verniers, bearing on the paper chart and turned by a crank. The paper chart is supported at the point of contact with the wheel by two small rollers, and the wheel is held against the chart by spring tension. The whole is held in place by the U-frame *B* that clamps onto the scale plate of the meter.

The frame *B* is $\frac{5}{16}$x1-in. black iron bent hot into a U-shape and smoothed up with a file. The No. 10-24 thumbscrew for clamping bears on a fiber block *C* that prevents damage to the scale plate. The fiber block is kept in place by a No. 6-32 screw *D* that passes through a loosely fitting hole in the frame, permitting enough movement to allow the thumbscrew to clamp the scale plate.

The rubber-tired wheel and its shaft of small drill rod are supported by a U-shaped bracket of $\frac{1}{16}$-in. sheet brass. This bracket is fastened to the frame *B* with two No. 6-32 screws. A small compression spring between the upper arm of the bracket and a washer backed up by a pin through the shaft, holds the wheel against the paper chart.

The rollers that enable the chart to slide under the rubber-tired wheel are $\frac{1}{4}$ in. in diameter with a small hole through them for a pin. The method of forming the ears to take the pins carrying the rollers is shown in the lower view on the sketch. First, a cut is made with a chisel to form the letter H on the end of the bracket. The two ends formed by making the crosscut

may then be bent up, the edges smoothed with a file and the holes drilled for the pins and the rollers. The bracket is then fastened to the underside of the frame with No. 6-32 screws so that the center of the rollers will come under the lower edge of the rubber-tired



Attachment permits chart to be revolved at uniform rate of speed

wheel. When in position on the scale plate, the rollers should just clear the plate that backs up the paper chart.

When the whole is assembled, clamp in place on the scale plate in the upper right-hand quarter. Pull up a little on the crank against the tension of the spring and slip the paper chart between the rubber-tired wheel and the rollers. Loosen the locking nut in the center of the chart and turn the crank in a clockwise direction. I have been told by engineers of the General Electric Co. that the best speed is about one revolution in three minutes. A few trials will show how fast to turn the crank. With this attachment the chart can be turned at a uniform rate of speed and calibration of the integrators becomes a pleasure. C. N. HUTCHINSON.

Albany, N. Y.

A Peculiar Belting Problem and Its Solution

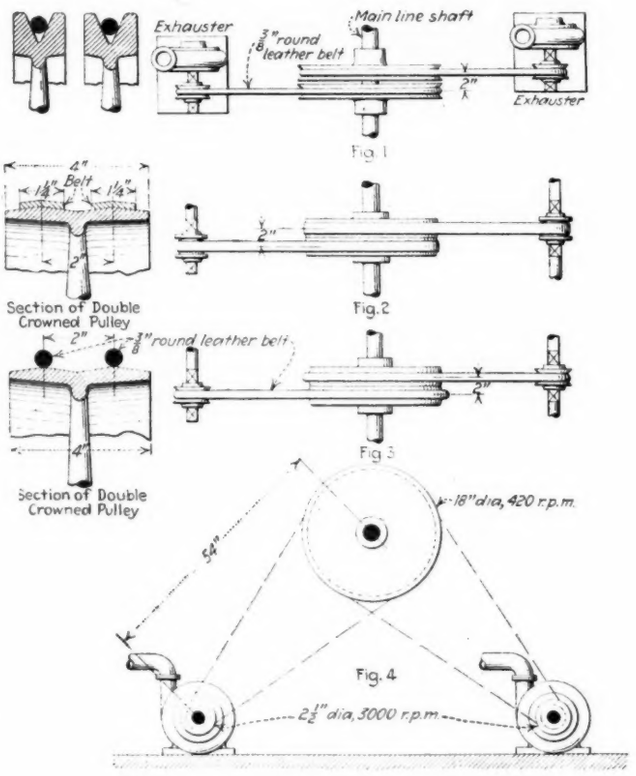
There are times when small low-powered transmission installations are most troublesome and aggravating from a maintenance point of view. Though small, they generally are important links in the production chain. The one illustrated herewith is very important, so much so that when it failed, production ceased.

In the final stage of manufacture metallic powder is dust-like, and in this stage it is sucked by small high-speed exhausters from certain machines and blown into receiving bins. These exhausters are in batteries and are individually driven by ⅜-in. round leather belting from a lineshaft. The exhausters cannot be driven by individual motors owing to electric trouble caused by dense metallic dust. The ⅜-in. round belts were installed and equipped with regular V-grooved pulleys. Figs. 1 and 4 show the original layout, giving speeds, diameters, etc. Endless trouble resulted. It was simply impossible to keep the belts on the pulleys because of whipping caused by the high speed and the dust.

Finally, it was decided to resort to flat single leather belting 1¼ in. wide. Owing to the arrangement of the exhausters it was necessary to operate the driving pulleys in pairs at 2-in. center-to-center distance, as Fig. 2 shows. A flange pulley of sufficient face to accommodate the 1¼-in. belt was installed on the exhausters. The driving pulley for the flat belts was made to accommodate two exhausters or with two crowns at 2-in. center-to-center, the belts driving in opposite directions. The flat belts worked well for a while, but finally, owing to dust, stretch and centrifugal force, began to give the same trouble as the round ones. The solution of the problem was finally found.

Two exhausters were equipped again with the round-belt grooved pulleys, and the ⅜-in. round belts were placed in service once more, operating over the double-crown driving pulley which had been previously used for the 1¼-in. flat belts. Fig. 3 shows this installation. The two round belts cling to the crowns of the driving pulley, regardless of dust, whipping or speed.

This solution was purely accidental, for if anyone had suggested such a method he would have been con-



Figs. 1 to 4—Types of drives used

Figs. 1 and 4—Plan and elevation of original drive. Fig. 2—Arrangement of flat belt drive. Fig. 3—Round belt on crowned driving pulley proved satisfactory.

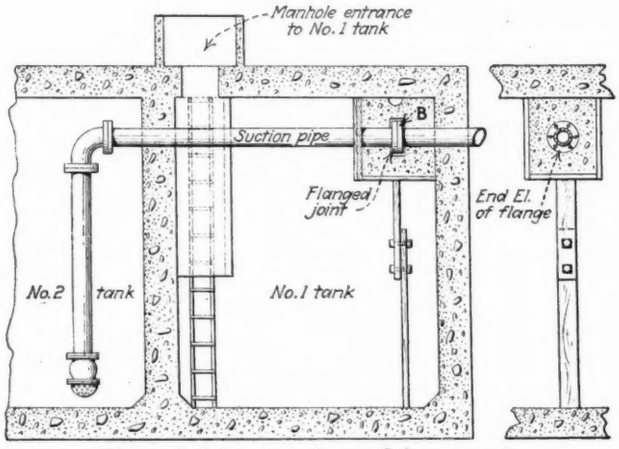
sidered a candidate for an asylum. However, the success of this apparently impossible drive is due to the fundamental principle that a belt, either round or flat, will climb to the high point of the pulley. In this case of a round belt on a crowned pulley, it rides to the high point and goes over and must then ride back to the high point again. Consequently, it is obvious that the belt will remain on the pulley.

Wilmington, Del. WILLIAM STANIAR.

Air Leak Due to Cracked Flange Stopped by Incasing Joint in Concrete

At the steam plant where I am employed, there are two large fuel-oil tanks, constructed of reinforced cement, as shown in the sketch. The tanks are placed underground and were built to the Fire Underwriters' specifications.

Referring to the illustration, it will be seen that the suction pipe from No. 2 tank, passes through the cement



Flanged joint was incased in concrete to stop air leak

partition wall between the tanks and the outer wall of No. 1 tank, the pipe being cemented in tight to prevent oil passing from one tank to the other or leaking away to waste.

On several occasions we were troubled with the fuel-oil pump losing its suction, the fireman having to make a hasty transfer from No. 2 to No. 1 tank. We were at a loss to account for the trouble, for occasionally, by simply letting the pump stand for a short time, the pumping could be continued again and the tank emptied without trouble. However, the trouble continued until the pump could not be depended on without someone to attend it most of the time, so we decided to examine the suction pipe to the pump at the first opportunity.

Upon entering the tank, we found the foot valve broken, so at once concluded that our troubles were solved. After installing a new foot-valve, we filled the tank and began pumping from it. The pump appeared to work perfectly for some time, but then the old trouble reappeared. The first time the tank was empty another examination of the foot valve was made, but this time it was found to be in good condition. We then concluded that there must be an air leak in the pipe.

At the first opportunity we examined the section of the pipe running through the No. 1 tank, and much to our surprise found one flange of the flanged union *B* cracked as shown at the right of the illustration. The next problem was to devise a way of repairing the joint without removing the pipe or destroying the seal between the pipe and the concrete wall of the tank. To weld it in place was out of the question, because of the explosive gases, so we decided to incase the joint in concrete. Accordingly, a wood form was built around the joint as shown, and the form was filled with concrete. Cardboard was placed around the flanges to permit of a little expansion without putting a stress on the concrete block.

This repair has completely eliminated our trouble. What caused the flange to crack is still a mystery. It may have been due to expansion or contraction, as the pipe is held solidly in the two walls, or it may have been done by the workmen when the tanks were constructed. The packing evidently prevented the leak from showing up for some time after the tanks were installed and then only intermittently.

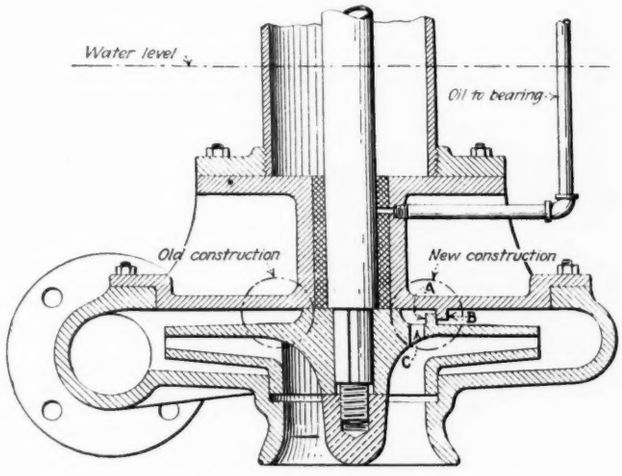
Vancouver, B. C., Canada F. E. BESCOLEY.

Improving the Lubrication of a Vertical Pump

The lubrication of a submerged vertical centrifugal pump usually presents a difficult problem owing to the tendency for the oil to float out of the bearing, which then becomes filled with water and grit and wears rapidly. One method of overcoming this is to use a heavy grease, but when grease is used, it is difficult to be sure the bearing is being lubricated at all. Usually, the grease pipe is not more than half filled, and the bearing runs dry.

A system that I have seen used with good results consists of a sight-feed lubricator, filled with lubricating oil and feeding into a vertical pipe that connects with the bearing. With this system it is necessary to alter the design of the pump, as shown, by adding sealing ring *A* to the back of the impeller, similar to rings used on horizontal pumps for balancing. Also, a ring *B* is added to the casing, and a series of holes are drilled through the impeller as indicated at *C*. The size and number of the holes vary, of course, with the size of the pump, a good average being six $\frac{5}{8}$-in. holes for a 3-in. pump.

On account of this change there is a slight suction exerted on the bearing at all times, and this draws the



Changes made in pump construction to improve lubrication of bearing

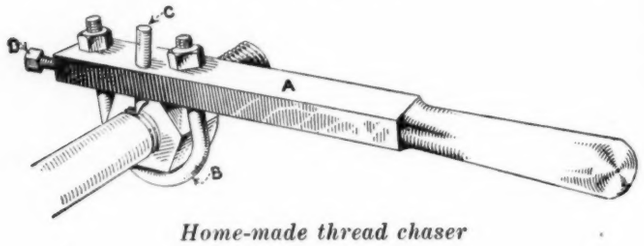
oil into the bearing. Without the ring the discharge pressure of the pump forces the oil out of the bearing, and if the pump runs continuously, the bearing is likely to run dry and wear rapidly.

The addition of the ring also makes the impeller hydraulically balanced, although this is usually of no great importance in this type of pump. The main advantage is in the improved lubrication.

Pittsburgh, Pa. RUSSELL K. ANNIS.

Tool To Extend Threads

When the threads of a nut are too short for the nut to be set tight and when washering up would not be practical, the tool shown in the illustration will be useful in extending the threads on the bolt without having to remove the bolt from its position. This tool should



Home-made thread chaser

be made of heavy stock if for large work, but for bolts up to ⅝-in. the sizes given will be suitable.

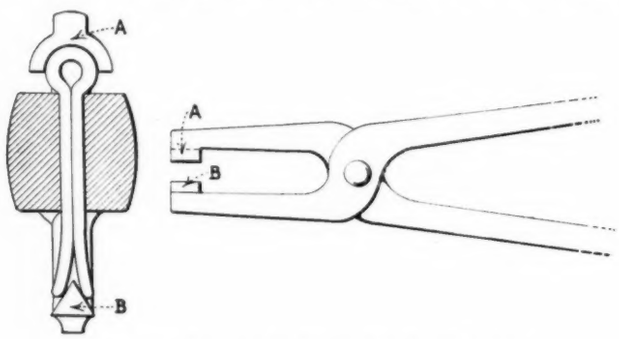
The handle *A* is made of ½x1-in. steel bar 12 in. long and the U-bolt *B* which clamps the tool to the nut is made of ⅜-in. round steel. Near the edge of the handle a hole is drilled for a ¼-in. round tool-steel cutter. This hole is drilled at an angle so that the point of the cutter *C* will be away from the nut and extend beyond the edge of the handle *A*. A setscrew *D* in the end of the handle locks the cutter at the desired position. The point of the cutter is ground to conform with the threads of the bolt, and with the nut turned off a few threads, the cutter is set to fit into the threads of the bolt. As the handle is turned, the nut is screwed on and the cutter, running ahead, cuts new threads up close to the surface against which the nut is to be set.

By reversing the tool, the threads on the end of a bolt that has become damaged can be recut before the nut is removed. G. G. McVICKER.

North Bend, Neb.

Tool for Replacing Cotter Pins

Replacing cotter pins in a long link chain used to convey ice in an ice storage is rather a tedious job by the ordinary method, mainly because the parts handled are small and cold and the surroundings are cold. In a certain storage all the cotter pins in a link chain



Pin spreader made from blacksmith tongs

about 200 ft. long were replaced. The chain was made up of links held together with pins having a head on one end and a hole in the other to receive a cotter pin. The cotter pins were ¼x1½ in., and the most tedious job was to spead the pin after it was inserted in the hole. The ordinary method of using a cold chisel and hammer to drive the prongs apart while holding a heavy piece of iron on the head of the pin was rather slow and this led us to devise a pin spreader as shown in the illustration.

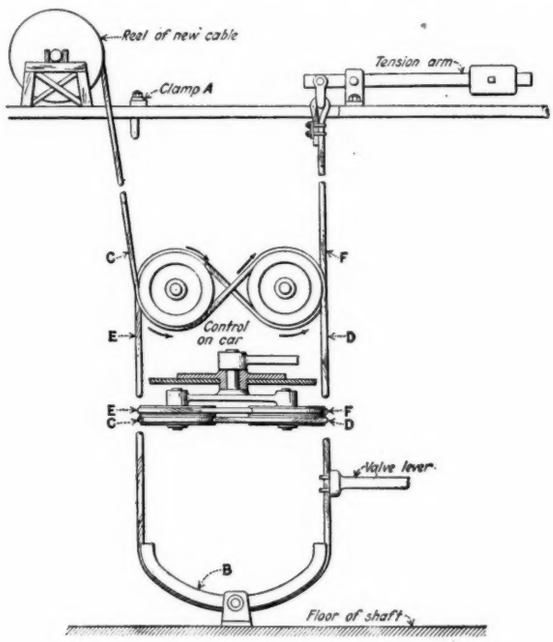
The spreader was made from a light pair of blacksmith's tongs. A small cup *A* to receive the head of the cotter pin was welded on one prong of the tongs and a wedge *B* to spread it on the other. The spreader was applied as shown and proved to be not only a convenient tool, by doing away with the use of the chisel, hammer and back stop, but a time saver as well.

St. Louis, Mo. H. E. MILLER.

Renewing the Control Cable on a Hydraulic Elevator

The method we used recently of cabling the control for a hydraulic elevator may be of interest to other readers of *Power*.

The spool of the new cable was first taken to the top of the shaft and the end of the cable passed down to



Arrangement of cable connections and control on car

the bottom of the shaft. After the old cable had been unclamped from the clamp *A* and removed from the sheaves on the car control, the new cable was run over the first pair of sheaves on the control, then around the half-sheave *B* and over the second pair of sheaves on the control. When this had been done, the end of the new cable was clamped to the old and drawn up to the top and fastened to the weighted arm called the tension arm. The cable was then cut off at the proper length and secured in the clamp *A*. The operating lever on the car was then placed on center, the operating valve placed in the neutral position, and the valve lever made fast to the cable. The car was then thoroughly tried out before turning it over to the operator.

By taking the reel of new cable to the top of the shaft, the labor and time expended in cabling the control is materially lessened. S. G. ROGERS.

Buffalo, N. Y.

Comments from Readers

What Caused the Exciter To Be Overloaded?

The letter by Pierre T. Willit in the Dec. 23, 1924, issue entitled "What Caused the Exciter To Be Overloaded?" recalls a number of similar experiences I had while employed as trouble man by a New York engineering concern. With reference to his letter, I do not believe that having all the wires in the conduit would have any effect on the machine, but the fact that the machine was driven by a much wider belt than others of larger capacity, leads me to believe that the trouble was due to an improperly made joint in the belt. Not infrequently, a bad joint causes a thump in a machine every time the joint passes over the pulley. This causes the brushes to jump and flat spots to form on the commutator. I know of a number of cases where trouble of this kind was overcome simply by making a proper slice in the belt.

I recall one instance in particular where this trouble was eliminated on a 50-kw. 125-volt generator that was belted to a countershaft. When I suggested to the master mechanic that a bad joint in the belt was the cause of the trouble, he as much as told me I was crazy and refused absolutely to alter the belt. But he did have the armature taken out and the commutator trued up in a lathe, after which the machine ran perfectly. Upon leaving the plant I remarked that he would be sending for me again in about six weeks, and sure enough he did. I again requested that he fix the belt, but he refused. In about two months he sent for me again, but this time he agreed to fix the belt. After that was done and the commutator trued up, the trouble never reappeared.

The fact that Mr. Willit thought the exciter was overloaded reminds me of a rather funny experience. Several years ago I was sent to install an arc-light machine in a small town not far from Buffalo. The machine was belted to a gas engine which also ran a two-phase alternator and an exciter that had been installed by another contractor. After my machine had been tested out, I spent some time watching the other contractor's men getting ready to test their unit. The exciter was a small compound-wound machine of about 1 kw. capacity and was belted to the alternator with a 4-in. belt. When the machine was started, the belt would not stay on. One man tried to hold it on with a stick, but when he held it on one side it would run off on the other side. After spending considerable time trying to get the belt to stay on the pulley they decided the machine was not properly lined up, so they removed the lagscrews that held it to the floor and endeavored to make the belt stay on by moving the machine at various angles. By this time I was becoming much interested and went over to help hold the machine in line. As soon as I put my hands on the machine, I noticed that it was quite hot and appeared to be overloaded. This was in the days when every generator had a pilot light and this little machine had a lamp connected across the terminals. Upon investigation it was found that there was a dead short circuit in the lamp socket. When the short circuit was removed the lagscrews were put back in the original holes and the belt ran perfectly.

Woodhaven, N. Y. FRANK F. REDDING.

Stratification of Gases in Furnaces Equipped with Chain-Grate Stokers

In an article in the Feb. 3 issue entitled, "Suggestions on Boiler Furnace Design," considerable space is devoted to the losses caused by the stratification of gases and how this condition is brought about in furnaces equipped with chain-grate stokers. One paragraph of the article reads as follows:

> The design of the chain-grate stoker is such that stratification is unavoidable. In practical operation the air leaking past the bridge wall and the end of the chain results in a stream of gases rich in oxygen passing directly into the tube space. At the same time, there is a stream of gases poor in oxygen and rich in products of distillation passing up from under the ignition arch. These two streams, one rich in oxygen and the other rich in products of distillation, never mingle in the furnace proper, and when they reach the boiler tubes they are cooled below the ignition point.

The author then points out that stratification is reduced considerably by using forced-draft chain-grate stokers, because the draft can be controlled to suit the fuel-bed conditions over the different sections of the grate, and that with this type of stoker a much smaller percentage of air leaks in between the bridge wall and the end of the grate.

From the foregoing statements it would seem that in order to avoid stratification with forced-draft chain-grate stokers, it would be necessary to prevent any air leakage between the end of the grate and the bridge wall and also to provide some means whereby the gases that are distilled from the fuel bed under the ignition arch may be supplied with sufficient oxygen to insure complete combustion before they reach the boiler-heating surfaces.

The air leakage around the end of the grate can be prevented by properly sealing the ashpit, either by the use of water seals or by keeping the doors in the ash hopper tight and by properly incasing the stoker.

The additional supply of oxygen necessary to insure complete combustion of the hydrocarbons distilled from the front sections of the grate can be obtained by injecting the proper amount of air through evenly spaced holes in the arch. The amount of air supplied can be regulated by partly closing the holes.

In some plants an air duct is placed across the top of the arch, the air being supplied to this duct by a small fan and the supply regulated by means of a damper in the fan discharge. Air is then admitted to the furnace through suitable openings in the arch which connect with the duct. In this way the amount

of air injected through the arch can be closely regulated to suit any desired rate of combustion.

The gases in the uptake of a boiler equipped with a forced-draft chain-grate stoker furnished with the aforementioned refinements will, when properly operated, show a uniformly high CO_2 content over a long period, thus indicating the absence of stratification and the losses incident thereto. PETER G. DAHL.

Chicago, Ill.

Welded Pipe Installations

The article by R. A. Cultra in the Jan. 6 issue, "Welded Pipe Installations," was of interest because such work with the oxyacetylene torch is an important part of that in the shop where I am employed. The following practical hints may be of interest to readers:

Welding operators must see that the pipes or pipe fittings are properly beveled and edges thoroughly cleaned from rust, scale and dirt. The pipes should be secured in position with suitable clamps, wedges, bolts, etc., with the proper distance between the ends to allow for the contraction of the metal and weld.

As each piping job presents a different condition in the matter of the expansion and contraction, one must realize first that something should be done to prevent the welded joint developing undue strains. It must be borne in mind at all times, that the expansion and contraction of metals when heated and cooled must be allowed for. A good practical method to counteract stresses due to distortion is to tack the branch pipe at intervals of 3 to 4 in. by small welds to the main pipe. Then weld the joint from these tacks alternately so that the "pull" is evenly distributed throughout the joint. The expansion of the main pipe gives a tendency to bend where the sections are cut away for the fitting of the branch pipes. This effect can be minimized or nullified by setting the pipe initially in the opposite direction and so allowing for this pull. For this to be accomplished with accuracy, experience is necessary.

The thickness of the metal should determine the nature of the joint. Beveling the ends to be jointed is not required on pipes lighter than $\frac{1}{8}$ in. in thickness. For thicknesses over $\frac{1}{8}$ in. the angle of bevel at the weld should be 45 deg. on each end, or a total angle opening of 90 deg. The beveling should be carefully done and extend the full depth of the material to be welded, as partial beveling tends to produce defective welds. Beveled pipe is now manufactured and sold approximately at the same price as ordinary piping.

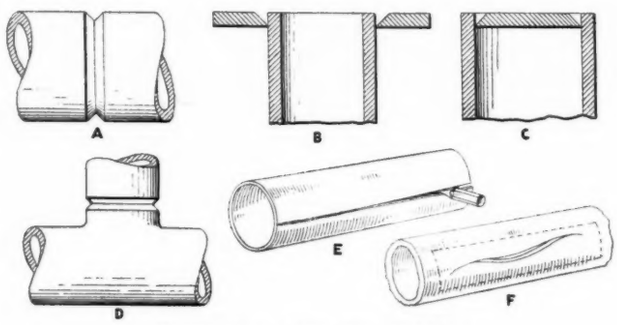
Galvanized water and gas pipe joints can be welded by the oxyacetylene torch, but in order to obtain leakproof pipe joints with this material, it is necessary first to remove the zinc protective coating from the vicinity of the weld before attempting to execute the weld. This means that the zinc coating must be entirely removed for a distance of 1 in. to $1\frac{1}{2}$ in. on either side of the weld. Without proper preparation sound welds on galvanized piping jobs are impossible as impurities such as zinc, slag, etc., invariably remain in the welded joint.

A principle to be observed in all oxyacetylene welding operations is never to direct the torch flame upon the welding rod to melt it. The flame should be directed against the pipe joint so as to form a puddle of molten metal. The welding rod should be melted by the heat of the puddle and the radiation from the torch flame. By always forming a puddle in the pipe joint V and adding to it from the welding rod, using the heat of the puddle to melt the rod, the welding operator is reasonably sure of obtaining penetration and cohesion.

A welding rod of diameter appropriate to the thickness of pipe being welded should be employed. The thicker the pipe the larger the welding rod up to a certain limit, but for steel piping jobs it is not advisable to use welding rods large than $\frac{3}{8}$ in. diameter, and most power plant piping jobs are done with rods of from $\frac{1}{8}$ to $\frac{1}{4}$ in.

Care should be taken to see that the V is filled with metal of the same nature and physical characteristics as the piping. For example, if the piping has a tensile strength of 50,000 lb. per sq.in., the weld metal should be of approximately the same strength. Therefore it will be seen that so far as welding rods are concerned it is essential that they should be carefully selected for chemical and physical properties.

The two ends of piping should be beveled as at *A* in the figure preparatory to welding. At *B* is shown a



Preparing pipe for welding

method of beveling a flange preparatory to welding it to the pipe. In some cases, pipe is also beveled to form a V, similar to the angle of bevel shown at *A*. The beveling at *C* is for a flat end to be welded inside of a piece of piping. A partly welded longitudinal seam *E* is shown on fabricated piping with a wedge set between the edges ahead of the weld, in order to obtain the correct separation and prevent overlapping. A good practical method of welding a branch pipe *D* on a large main pipe, is to draw out the large pipe. Another method of welding a branch pipe or tee connection on a large pipe is to flange the end of the branch pipe to fit closely to the contour of the main pipe. The preparation shown is recommended, however, in preference.

In the figure at *F* is a practical method of repairing a ruptured or broken pipe with the oxyacetylene torch. The job is effected as follows: In the case of a longitudinal fracture, cut away the defective metal leaving a rectangular hole in the pipe as shown by the dotted lines in the sketch. Procure a rectangular patch of the same thickness and radius as the pipe wall. If this thickness is $\frac{1}{8}$ in. or more, the edges of both the hole and the patch should be beveled as previously explained. Weld a piece of $\frac{1}{4}$- or $\frac{3}{8}$-in. diameter rod to the patch to serve as a handle by which it can be held in place during welding. This can be readily cut off after the welding is finished. By this simple method it is oftentimes possible to effect satisfactory repairs on power-plant piping at very small expense, with the advantage of being permanent. E. ANDREWS.

Manchester, England.

Questions and Answers

Conducted by

Franklin Van Winkle

Hot-Water Supply to Outlet Below Tank

In a new installation of hot-water service for a public building, the supply line is extended to the top of the building and is returned to the heating tank, but we are unable to draw hot water from the return line on a floor that has about the same elevation as the hot-water tank. How can the trouble be corrected? *L. H. C.*

When a faucet connected with a return line is opened, cold water will back up to the faucet if it is not at a level considerably above the top of the hot-water tank. Fixtures on the same or lower levels than that of the tank should be supplied by a line without return, taken out of the top of the tank or out of the main riser close to the tank.

Use for Oil Separator on Exhaust-Steam Heating System

Why should an oil separator be used with an exhaust-steam heating system? *B. N.*

Nearly all of the oil that is supplied for lubrication of engine and pump cylinders is expelled, suspended in the exhaust steam. Unless separated from the exhaust before it is supplied to a heating system, much of the previously entrained oil becomes deposited in the pipes, valves, fittings and radiators, often causing leakage of joints, destruction of packing and gumming of vacuum and air valves. The use of oil separators is all the more necessary where the condensate is used for boiler feeding, as continuous use of boiler feed water containing the smallest traces of oil is likely to result in burning of boiler sheets or tubes without warning.

Pounding of Simplex Pump

After replacing our duplex boiler-feed pump with a 12x7x12-in. simplex feed pump for supplying five return tubular boilers, we are greatly annoyed by hammering and loosened joints in the feed lines. An air chamber placed on the end of the feed line appears to be of no benefit. The duplex pump did the same work smoothly and without noise. How can the trouble be prevented? *F. M.*

The discharge by a simplex pump is not so uniform as that of a duplex, and for smooth running the simplex pump should be provided with an air chamber having six to eight times the capacity of the water cylinder. However, air chambers are worthless for reducing shocks unless they receive proper attention to insure presence of sufficient air for a good cushioning effect, since the air soon becomes absorbed by the water when they are brought together at the pressure of the pump discharge. Shocks from pounding can be reduced also by running the pump slower, which of course would be practical only if boiler feeding can be more continuous.

Feed-Pipe Bushing

Why is a bushing used for connecting a feed pipe to a boiler? *C. R. D.*

A bushing, generally made of brass, is used to act as a coupling for extension of the feed line to a perforated pipe inside of the boiler, so the feed water may be heated to about the same temperature as the boiler water before it comes in contact with the tubes or plates. As the exterior of the bushing is of larger diameter than the feed pipe, it affords a firmer hold on the boiler sheet than a tapping only large enough for the pipe size, and in addition the screw threads in the boiler sheet are protected from injury that would result from rusting and jarring of the feed pipe.

Increasing Back Pressure in Ammonia Refrigeration Plant

Our ice plant is equipped with one single-cylinder double-acting compressor 13x26 in., 65 r.p.m., and one having two double-acting cylinders each 10x30 in., 65 r.p.m. We operate at 20 lb. gage back pressure, which it is intended to increase to 28 lb. gage. The cooling water has a temperature of 85 deg. F. and the condenser pressure is not to exceed 190 lb. gage. What number of square feet of cooling surface, or feet of 2-in. pipe, would be required, and what number of gallons of cooling water should be discharged per minute over the condenser? *T. E. F.*

First determine the amount of heat to be removed. This depends on the weight of gas handled per minute. The theoretical volume of gas handled per minute by the 13x26-in. compressor is found by the formula,

$$V = 0.7854\ D^2LN,$$

where V = vol. in cubic feet of suction gas handled, D = diameter of cylinder in feet, or $\frac{13}{12}$, L = length of stroke in feet, or $\frac{26}{12}$, and N = number of strokes per min., or $65 \times 2 = 130$.

Substituting these values gives

$$V = 0.7854 \left(\frac{13}{12} \times \frac{13}{12} \times \frac{26}{12}\right) \times 130 = 259.6\ cu.ft.\ per\ min.$$

The two-cylinder 10x30-in. double-acting compressor would handle a volume $V = 0.7854 \left(\frac{10}{12} \times \frac{10}{12} \times \frac{30}{12}\right) \times 130 \times 2 = 254.5$ cu.ft. per min. and the theoretical volume of gas handled by two compressors at suction pressure 28 lb. gage would be $259.6 + 354.5 = 614.1$ cu.ft. per min. At the pressure of 25 lb. gage, or 43 lb. absolute, one cu.ft. of dry saturated ammonia vapor weighs 0.153 lb.; hence 614.1 cu.ft. weighs 93.95 lb., and with a volumetric efficiency of 80 per cent the compressors handle 75.16 lb. of ammonia per minute.

Goodenough's tables of properties of ammonia show that each pound of ammonia vapor at 43 lb. absolute contains 542.8 B.t.u.; that is, 75.16 × 542.8 = 40,796 B.t.u. enters the compressor per minute. The tables also reveal that the entropy of the ammonia, which is a property that remains constant during an ideal compression, is 1.1407.

After compression the discharge pressure is 190 gage, or 205 lb. absolute. From examination of tables of superheated ammonia it is found that at the pressure 205 lb. absolute and entropy 1.1407, the gas would have a final temperature of 220 deg. F. and a heat content of 640 B.t.u. per pound, or a total heat of 75.16 × 640 = 48,102 B.t.u.

The condensing temperature of ammonia corresponding to 190 lb. gage is approximately 97 deg. F. The heat in each pound of liquid ammonia leaving the condenser at this temperature is 74.2 B.t.u. or a total of 75.16 × 74.2 = 5,576 B.t.u. The condenser has then removed 48,102 — 5,576 = 42,526 B.t.u. per minute.

The amount of heat removed per square foot of heating surface per hour depends upon the temperature difference between the entering ammonia vapor and the entering water, and that between the outlet water and leaving ammonia liquid, as well as upon the coefficient of heat transfer per degree of temperature difference. This coefficient varies with the type of condenser, and in the absence of such information could be taken as 120 B.t.u. per hour, or 2 B.t.u. per min. The heat per square foot is then KT, when $K = 2$ and $T =$ the mean temperature difference. To find T, the inlet water is 83 deg. and the outlet is assumed to be 93 deg.; the inlet gas temperature is 220 deg. and the exit liquid temperature is 97 deg. The mean temperature difference T is found by the equation

$$T = \frac{(220\text{-}85) - (97\text{-}93)}{\frac{(220\text{-}85)}{(97\text{-}95)}} = 31.6 \text{ deg.}$$

Then inserting the values of K and T, we have

$$H = 2 \times 31.6 = 63.2 \text{ B.t.u. per sq.ft.}$$

A total heat removal of 42,525 B.t.u. would call for 42,525 ÷ 63.2 = 672.8 sq.ft. Since 1.6 ft. of 2-in. pipe is required for 1 sq.ft. of surface, there would need to be 672.8 × 1.6 = 1,076 ft. of 2-in. pipe.

The amount of cooling water needed is found from the rise in cooling-water temperature, which is here assumed to be 93 — 83 = 10 deg., and the 42,526 B.t.u. to be removed calls for 4,252 lb., or approximately 510 gal. per min. However, in all probability the temperature of 93 deg. F. will not be reached, and 90 deg. F. may be nearer the results to be obtained for the outlet temperature of the water, and if this value should be used in the calculation, the amount of water required would be $\frac{10}{7}$ of 510 = about 728 gal. per min. and there should be a corresponding increase of surface.

Unbalanced Area of Water Leg

What is the unbalanced area in the water leg of a vertical fire-tube boiler? R. G.

When the circular furnace is stayed from the outside shell of the water leg, only as much area of the outer shell can be constructed to be supported by the stays as the equal stayed area of the furnace sheet. Hence, the unbalanced area is the area of the stayed portion of the outside shell that is in excess of the stayed area of the furnace sheet.

Calling the diameter of the furnace sheet d in., diameter of outer shell D in., and height of furnace h in., the unbalanced area would be

$$(D \times 3.1416 \times h) - (d \times 3.1416 \times h) = 3.1416\, h\, (D - d) \text{ sq.in.}$$

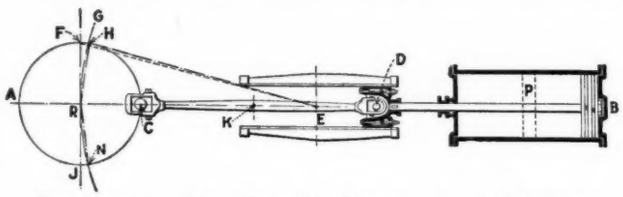
Then if $p =$ the working pressure per square inch, the total unbalanced pressure would be $p \times 3.1416\, h\, (D - d)$ pounds. Since the area of that part of the outside shell which is reinforced by the stays is $(D \times 3.1416 \times h)$ sq.in., the unbalanced pressure per square inch that must be sustained by a longitudinal joint of that part of the outside shell which is reinforced by the stay-bolts is

$$p \times 3.1416\, h\, (D - d) \div h \times D \times 3.1416 = p\, (D - d) \div D$$

Position of Crank at Half-Stroke of Piston

Why does not the crank of an engine stand perpendicular to the engine center line when the piston is at one-half stroke? L. C.

Referring to the diagram, suppose AB is the center line through the engine crankshaft and cylinder, CD the length of the connecting rod, and $CHFAJ$ is the circle described by the center of the crank. When the



Crank moves less than 90 degrees for half stroke in head end of cylinder

piston is at P, halfway on its stroke, and the crosshead pin is carried to E, the connecting rod, from center of the crosshead pin to the center of the crankpin, would be long enough to reach from E to the center R of the circle described by the crankpin. But if FRJ is perpendicular to AB, the connecting rod with length RE could not reach from E to F, since in the right angle triangle FRE, the hypotenuse FE is greater than the base RE. If with E as a center and radius equal to CD or RE, we describe the arc GRN, the points of intersection H or N, would be the position of the crankpin when the connecting rod reaches from E to the crank circle. Both H and N must be on the crosshead side of the perpendicular FRJ, and it follows that the crank angle HRE or NRE must be less than a right angle when the piston and crosshead are each at the middle of their travel. It is to be observed that while half-stroke of the piston in the head end of the cylinder is accomplished during less than 90 deg. rotation of the crankshaft, there is more than 90 deg. of rotation accomplished while the piston is traversing one-half stroke in the crank end of the cylinder, and as the eccentric makes the same number of degrees of rotation as the crankshaft, this variation, due to angularity of the connecting rod, must be taken into account in the design and setting of valves moved by the eccentric.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—EDITOR.]

A new slant on things observed in and out of the power plant

What Happens and Why?

Why Stage Heating Saves Fuel

THE rather peculiar arrangement of engines and closed heaters shown on this page is not intended to be a practical power-plant layout. First cost and complication would prohibit such an installation. The purpose is rather to picture a demonstration outfit for showing why it saves fuel to heat the feed water in stages.

With a few simplifying assumptions this can be clearly shown without recourse to entropy or any other abstruse conception. The conditions shown on the diagrams are assumed to hold constant throughout the comparison. A constant amount of dry saturated steam, 10,000 lb. per hour, will be supplied to the system through the throttle of engine *A* at a pressure of 200 lb. absolute. This engine will exhaust saturated steam at 80 lb. absolute (312 deg. F.). The closed heater *A* will at all times be connected to the exhaust of engine *A*, so that (assuming no final temperature difference in the heater) the final temperature of the feed water leaving heater *A* will be 312 deg. Final temperature differences will be neglected throughout.

Thus the work done by the boiler will be the same in every case, consisting of the production of 10,000 lb. of dry saturated steam at 200 lb. pressure per hour from feed water at 312 deg. It will be assumed that the exhaust of *D* passes to a jet condenser and is wasted, but that any desired portion of this exhaust may be bled to heater *D* supplied with 100 per cent makeup water at 60 deg. F.

The pressures and temperatures of the steam at various points are assumed to be as shown in Table I.

Each heater connected will be assumed to heat the feed water to the corresponding steam temperature. The condensate will be thrown away after giving up its latent heat. For simplicity it will be assumed that each engine has a water rate of 100 lb. per hp.-hr. and that the steam is dry saturated throughout its expansion, which would be approximately true for this water rate.

TABLE I—STEAM PRESSURES, TEMPERATURES AND LATENT HEATS

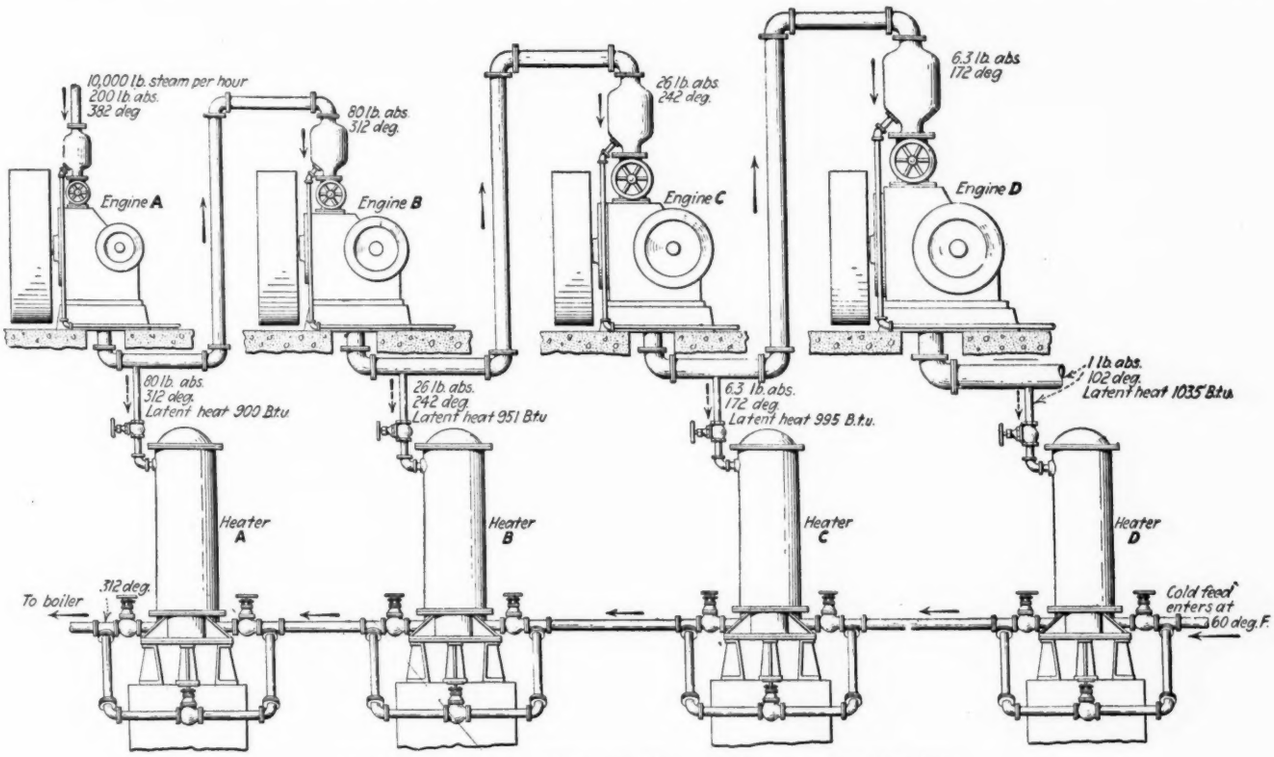
Engine and Point	Absolute Pressure, Lb. per Sq.In.	Temp., Deg. F.	Latent Heat, B.t.u.
Throttle of *A*	200	382	....
Exhaust of *A* / Throttle of *B*	80	312	900
Exhaust of *B* / Throttle of *C*	26	242	951
Exhaust of *C* / Throttle of *D*	63	172	995
Exhaust of *D*	1	102	1,035

With these assumptions it will be a simple matter to study the effect of turning on various heaters upon the total power produced from the constant boiler output.

First assume that only heater *A* is on, which must then heat 10,000 lb. of feed water per hour from 60 to 312 deg. The steam required will be 10,000 × (312 − 60) ÷ 900 = 2,800 lb. of steam per hour.

Then 10,000 lb. per hour of steam will flow through engine *A*, developing 10,000 ÷ 100 = 100 hp. The steam flowing through each of the other engines will be 10,000 − 2,800 = 7,200 lb. per hour. This will develop 7,200 ÷ 100 = 72 hp. in each, or a total of 100 + (3 × 70) = 100 + 210 = 310 hp. for the whole plant.

Next open the valve to heater *D* as well. This will heat the feed from 60 to 102 deg. without the loss of any useful steam. Heater *A* will now take less steam, it being supplied with 102-deg. water from heater *D*. The steam consumption of heater *A* will become 10,000(312 − 102) ÷ 900 = 2,330 lb. per hour. This leaves 7,670 lb. flowing through cylinders *B*, *C* and



Imaginary plant to illustrate the principle of stage heating

D and gives power developed as shown in Table II.

TABLE II—STEAM FLOW AND POWER WITH HEATERS *A* AND *D* OPERATING

Cylinder	Steam Flowing	Horsepower
A	10,000	100.0
B	7,670	76.7
C	7,670	76.7
D	7,670	76.7
Total		330.1

This is a substantial gain over operation with heater *A* alone. The saving in this case is obvious since heater *D* is using waste heat. It will be interesting to study the effect of turning on heaters *B* and *C* as well.

Next open the valve to heater *B*, which will heat the water from 102 deg. to 242 deg. with steam having a latent heat of 951 B.t.u. To do this will require 10,000(242 — 102) ÷ 951 = 1,470 lb. of steam per hour to be bled to heater *B*. The task of heater *A* will be reduced, since it will have to heat the water only from 242 to 312 deg., the steam required being 10,000(312 — 242) ÷ 900 = 780 lb. per hour. The amount passing through each cylinder can now easily be figured by starting with 10,000 lb. at the throttle of *A* and dropping off the amounts bled. The figures with the corresponding amounts of power developed are shown in Table III.

TABLE III—STEAM FLOW AND POWER WITH HEATERS *A*, *B* AND *D* OPERATING

Cylinder	Steam Passing Through, Lb. per Hr.	Power Developed Hp.
A	10,000	100.0
B	9,220	92.2
C	7,750	77.5
D	7,750	77.5
Total		347.2

Here again is a further gain though less than before.

Next open the valve to heater *C* so that all the heaters are in operation. The amount of steam then flowing through each cylinder and the corresponding power developed will be as shown in Table IV.

TABLE IV—STEAM FLOW AND POWER WITH ALL HEATERS OPERATING

Cylinder	Steam Passing Through, Lb. per Hr.	Power Developed, Hp.
A	10,000	100.0
B	9,220	92.2
C	8,484	84.8
D	7,780	77.8
Total		354.8 hp.

For comparison the results obtained so far may be classified as shown in Table V, which shows that it makes a substantial difference how the feed is heated.

TABLE V—COMPARISON OF POWER OBTAINED WITH SAME BOILER OUTPUT

Heaters in Operation	Total Power From Constant Boiler Output	Relative Power
A	310	100
A & B	330.1	106.5
A, B & D	347.2	112
A, B, C & D	354.8	114.5

So far as heat alone is considered, the ideal is to heat the feed water in as many steps as possible. Whenever bled steam is used to heat feed water at a considerably lower temperature than the steam, the chance is missed of doing the first part of this heating by steam from which a little more work had been obtained by allowing it to expand to a lower temperature before going to the heater.

The first heat to use is that in the final exhaust, since the steam so used has no value whatever for power production.

The arrangement shown practically never occurs in practice. However, compound engines are fairly common and this permits heating from two stages, the low-pressure exhaust and steam bled from the receiver. The exhaust of steam-driven auxiliaries will often give a third heating pressure. Again some units may be running condensing and some non-condensing (this includes auxiliaries), so that two-stage heating may be used without difficulty.

In turbine plants it is becoming customary to tap or bleed the turbines at various stages for heating feed water in steps. Then again it is possible to bleed the turbine at one or two points and use these in conjunction with steam from auxiliary exhaust and house-turbine exhaust. The combinations possible are infinite.

The figuring of the best combination in practice, allowing for such factors as cost of apparatus, temperature drop in heaters, partial recovery of the heat in the condensate of the high-pressure heaters, etc., is a rather tedious computation although no "higher mathematics" are required. Where the engineer sees the possibility of saving by stage heating and is not himself thoroughly conversant with this type of computations, he might well secure the assistance of a consulting engineer or of a manufacturer of heating equipment to determine the layout that will give the greatest commercial economy.

This article will have served its purpose if it gives the reader a conception of the fundamental reason for stage heating.

Geared Turbines for Ship Propulsion

The history of geared turbines for ship propulsion, including a description of present-day operating conditions, was reviewed by Warren B. Flanders, Turbine Engineering Department of the Westinghouse Electric & Manufacturing Co. at a meeting of the Metropolitan Section of the A.S.M.E., March 11, 1925.

In the early days of turbine development George Westinghouse became impressed with the possibilities of geared-turbine drive for cargo vessels. The smaller tonnage and lower speed rendered this type of ship less suitable for the direct-drive turbine which was successfully used for passenger service.

As a result of the co-operation of Admiral Melville, the first geared drive was placed in service in 1909. This was the Melville-Macalpine design, a certain flexibility permitting alignment of the power in one plane, which type has been since adhered to.

Little was accomplished in the matter of equipping ships with this drive until the war period. In a few years a tremendous amount of propulsion machinery with both single- and double-reduction gears, single, cross-compound and divided-flow turbines was installed on destroyers, tankers, colliers, etc. Recently, however, the lack of shipbuilding in this country has greatly curtailed production.

Experience to date shows many such drives having service records of 250,000 miles and upward, but with no evidence of serious wear. The collier "Neptune" completed 350,000 miles with no major repairs. Gears can be produced up to 25,000 hp. in a single unit. Quiet operation requires primarily accuracy in manufacture. A small flexible shaft connection between the pinion and driving turbine has proved beneficial.

A simple maneuvering gear contained a single hand-operated wheel connected to both the ahead and astern admission valves through a crankshaft and connecting rods. Piping was recommended to be placed above the units for reasons of accessibility.

Cleanliness of steam and oil and proper drainage at all times, especially when shut down, are the simple rules which, nevertheless are sometimes disregarded. Inadequate means of drainage are sometimes encountered wherein the starting up process subjects the turbine to water conditions of a degree not tolerated in land practice.

Conditions were reviewed showing costs of operation relative to reciprocating engines. From the fact that a modern steam plant can produce the equivalent of a shaft horsepower on 0.6 lb. of oil, it appears that much benefit is to be derived from the application of higher pressures and other improvements aboard ship. A passenger boat with 500 lb. steam and other refinements should require 0.595 of oil per shaft horsepower. This leaves little margin of economy for Diesel engines.

In the discussion that followed, the effect of air in the feed water as causing blade erosion was brought out. This appears around the dew point in the path of expansion, representing the area where the superheat is exhausted. When salt water does get into the boiler feed, it has been found that salt tends to come over as a solid, also producing erosion.

State Ownership Project in Oregon

Advocates of the Clear Lake water and power project on the McKenzie River in Oregon have watched with interest the progress of a resolution fathered by State Senator Joseph, which would refer to a vote of the people an amendment to the constitution permitting the state to go into the power business. The Clear Lake project was intended primarily to deliver mountain water from this lake, which is near the source of the McKenzie River, to the towns in the low-lying Willamette Valley.

Because of the cost of the project it was expected that several towns from Salem to Eugene would unite in a water district. Estimates have been made tending to show that about 50,000 hp. could be developed and delivered to these towns at a cost that is practicable, and the advocates of the project believe that if the proposed state power bill eventually becomes a law, the way will be made easy for the realization of their plans.

Philadelphia Engineers Club Holds Third Hydro-Electric Conference

OPERATING hydro-electric plants to obtain maximum efficiency was the keynote of the Third Hydro-Electric Conference, held under the auspices of the Philadelphia Engineers Club, March 10. At the morning and afternoon sessions, which were held in the auditorium of the Manufacturers' Club, Philadelphia, seven papers were presented dealing with practical problems in the design and operation of hydro-electric equipment. The evening session, which was held in the ball room of the Bellevue-Stratford Hotel, was preceded by a dinner, after which addresses were made by Dr. William F. Durand, president, American Society of Mechanical Engineers, Arthur E. Pope, assistant to the president of the New England Power Co., Boston, Mass., and Charles E. Penrose, assistant general manager, Day & Zimmermann, Inc., Philadelphia, Pa.

The morning session was presided over by Dr. Arthur M. Greene, Jr., Dean of Engineering, Princeton University, and was opened by an address by Conrad Newton Lauer, president of the Philadelphia Engineers Club. At the afternoon session Dr. Robert H. Fernald, Director Mechanical Engineering Department, University of Pennsylvania, presided. President Conrad Newton Lauer was toastmaster and presiding officer at the dinner and evening session.

OPERATION of hydro-electric systems with auxiliary steam plants; operation of hydro-electric units for maximum kilowatt-hours; interrelation of operation and design of hydraulic turbines; operating practice in hydro-electric development; recent developments in hydro-electric generator design, are among the subjects considered.

Hydro-Electric Plant Operation

"The Operation of Hydro-Electric Systems with Auxiliary Steam Plants for Best Economy and Proper Governing," by William M. White, chief engineer, Hydraulic Department of the Allis-Chalmers Co., was the first paper presented at the morning session. The speaker outlined the fundamentals of hydro-electric operation as affecting or affected by the operation of steam plants and showed that, contrary to popular notion, it is often more economical during low-water season to operate the steam plant on base load and take the peak or swings of the load on the hydro-electric plants.

After discussing a number of conditions under which hydro-plants are operated in combination with steam stations, Mr. White expressed the opinion that the operations he outlined could be planned for proper and economic operation if the length of the low-water season were definitely known and if the flow of the river could be fairly well predicted. When the vagaries of the climate, and sudden seasonal changes in the locality of any given hydro-electric system are added to the problem, there is introduced such uncertain and variable factors, combined with the uncertain power load and even more uncertain peak demands, that the problem becomes a complicated one. In large hydro-electric systems requiring steam auxiliaries these, in the opinion of the speaker, may well be made of varying characteristics; for example first, a steam plant or plants designed with highest economy for raising the base load of the hydro-electric plants, and second, heavy-duty steam plants of lower first cost for taking the peaks of the load.

It was pointed out that for best economy in hydro-electric plants having a number of identical units, best efficiency can be obtained by dividing the load equally between those units in operation. The setting of governors in stations having duplicate efficiency curves should be such that they have the same inherent regulation. Where the efficiency curves of the units are different the governors should be adjusted to make the regulation of the units different. Those units having high-part-load efficiency, should have small inherent regulation. Those units having lower part-load efficiency should have greater inherent regulation, so that under changes of load the greater percentage change of load will come on the more efficient units.

Mr. White described a method for the governing of hydro units that must be kept in readiness to meet large load demands. This method consists in running a unit or units synchronized on the line with the gates completely closed and draft tubes vented. The pilot valve of the synchronized idling unit is maintained in position for closed gates by interconnection with the gate mechanism of one of the units in regular service, and so long as the gates of the unit in regular service are within predetermined and prescribed limits, the pilot valve of the idling machine holds the turbine gates closed. When, however, the demand for power is such that the gates of the units in service are moved toward wide-open position, then the pilot valve of the governor of the idling unit is released and load is put upon the idling unit as quickly as would have occurred had the unit been regularly governing with gates in position for no power output on that machine.

In the absence of Forrest Nagler, of the Allis-Chalmers Co., his paper "Operation of Hydro-Electric Units for Maximum Kilowatt-Hours," was presented by William M. White. The author suggests a number of ways of reducing the losses in hydro-electric plants. One of these is the venting of reaction turbine runners; that is, the admission of air to some portion of the runner or the passage surrounding it, for improved part-gate efficiency. Practically all Francis runners, particularly those of medium or high specific speed, have a dead center in the water discharging from them. This may be simply a center of reversed rotation or of no rotation, or it may be even reversed in direction, flowing upward or toward the runner from the discharge side, passing radially outward into the runner and again discharging from it. Venting of runners secures gainful effect either by reducing this pumping action which consumes power or by reducing the wetted surface of the runner which is dragged around in the water and consumes power that might be otherwise delivered to the generator.

Reducing Gate Leakage

As a second method of increasing the output, reducing gate leakage is proposed. Gate leakage should, in the opinion of the author, be less than one per cent of the full discharge of the unit. This gate leakage goes up rapidly with the age of the machine, unless the utmost refinement of design of the gate mechanism is resorted to. Three per cent is not uncommon for gate leakage in plants six to nine years old, and 5 to 10 per cent are frequently found, these figures being mentioned based on some actual measurements. A 6 per cent gate leakage on 50 per cent idle machines means that 30 per cent of a 10 per cent net income is being thrown away in place of the possible 5 per cent, as it should be.

A third method proposed for reducing losses is the operation of impulse wheels, which, assuming good modern design in needle-type nozzles, amount to 2 to 5 per cent; bucket loss, including the outflow, 5 to 10 per cent; and the windage loss 2 to 5 per cent. Friction is practically a negligible quantity. The greatest improvement can, in the author's opinion, be made in the first two, since bucket design is probably farther advanced than any other part of the turbine. Mr. Nagler also proposed setting impulse wheels higher above tail water than is now the practice and using draft tubes to obtain a vacuum in the casing to reduce the windage loss.

On account of the increased cost of the station and equipment, caused by their use and the interruptions to service, it is proposed that the governor be eliminated or be so modified that it is a control rather than a governor, having 30 to 60 sec. operating time in place of two seconds. It was pointed out that in the last few years some 20 units, of over 1,000 hp. each, have been built without governors. Their operation to date has been everything that has been expected of them from a viewpoint of convenience, service and reliability and much beyond expectation from a viewpoint of kilowatt-hours produced.

The important relations between operation and design of hydraulic turbines was treated of in a paper, "Inter-Relation of Operation and Design of Hydraulic Turbines," by Frank H. Rogers, chief engineer, and Lewis F. Moody, consulting engineer, I. P. Morris Dept., Wm. Cramp & Sons Ship & Engine Building Co. Under the heading of selection of the type or runner, it was pointed out that frequently turbines of high speed are chosen merely from the consideration of first cost and without proper regard for stream flow and part-load operation. In many cases the latter factors play an important part, permitting an increase in yearly output for lower speed units, of greater monetary value than the interest charge on excess in first cost.

Determining Load Division

Under the subject of load division was shown a method of determining the proper division of various flows between units in a plant to result in maximum output for each flow. Output-discharge curves of different types were considered and a general method of investigation was outlined, which can be applied to any particular installation after the shape of the output-discharge curves of the units has been determined.

The selection of type of turbine to avoid conditions conducive to pitting or corrosion was presented from a new viewpoint. Instead of selecting specific speed from an "experience curve" plotted between specific speed and head, it was proposed that selection be governed by reference to the minimum absolute pressure to be expected at a local point within the turbine. The drop in pressure below atmosphere is expressed as the sum of static draft head, velocity head regained in draft tube, and a local pressure drop proportional to the head on the turbine. Effects were considered of variation in operating conditions such as overload operation and variation of tailwater level.

Operating Problems and Their Relation to Design

A paper on "Operating Problems and Their Relation to the Design of Hydro-Electric Machinery," by Ely C. Hutchinson, vice-president, Pelton Water Wheel Co., described a number of installations on the Pacific Coast. Among these were two 25,000-hp. reaction-type turbines operating under 810-ft. head and running at a speed of 500 or 600 r.p.m. depending on whether the generator is connected to a 50- or a 60-cycle system. Another notable unit referred to is the 35,000-hp. reaction turbine operating under a head varying from 850 to 930 ft. at a speed of 514 r.p.m. This unit holds the record for head on a reaction-type wheel. The record for capacity in an impulse unit is one of 35,000 hp. of the double-overhung type for operation under a 1,900 ft. head at 300 r.p.m. Studies have been made on units for 70,000 hp. under a 2,100 ft. head, and according to Mr. Hutchinson it is not unlikely that machines of this size will be built in the near future, as they present no great difficulties.

Charles B. Hawley, consulting engineer, Washington, D. C., in presenting his paper, "Operating Practice in Hydro-Electric Development," said that operating methods should be improved and not wait for further improvement in turbine design, and this has been carried to a very high state of development. The speaker suggested ways and means of improving the design of intakes and penstocks and laid particular emphasis on improving the tailrace channel to prevent high back water. It was his opinion that not to take advantage of the gain in power that can frequently be obtained by improving the tailrace channel to maintain the water as low as possible, was a short-sighted policy.

M. C. Olson, of the General Electric Co., in a paper, "Features of Design in Latest Large Hydro-Electric Generators," described a number of modern units. One of the remarkable features of these units is their high efficiency. The 65,000-kva. units for the Niagara Falls Power Co. have a guaranteed efficiency of 98.1 per cent at full rated load and unity power factor, 97.8 per cent at 90 per cent power factor and 97.5 per cent at 80 per cent power factor.

Developments in Hydro-Electric Generators

F. D. Newbury, manager, Power Engineering Department, Westinghouse Electric & Manufacturing Co. compared construction of hydro-electric generators with steam-turbine driven units and gave some examples of modern waterwheel generator design in a paper, "Recent Developments in Hydro-Electric Generators." Mr. Newbury stated that an outstanding characteristic of the hydraulic-turbine generator, considered from the designer's point of view is its diversity of form. Each new installation is likely to require special consideration with respect to size of generator, speed, flywheel effect, ventilation, and in the case of extra-long-distance transmission particularly careful attention must be given such electrical characteristics.

In the discussion on these papers it was pointed out that it was bad practice to leave hydraulic turbines standing with pressure in the casing. This practice not only causes leakage through the wicket gates, which results in waste of water, but this leakage may strike the runner in such a way as to cause pitting. If the penstock valve is closed this leakage will be largely eliminated along with its bad effects.

Doing away with the governor was not generally agreed to by those taking part in the discussion; this part of the equipment was accredited with doing the thinking for the whole power-house staff. Where hydro-plants operate with steam stations, it might be all right to do away with the governor on the hydro units, provided they did not represent too large a part of the total capacity. In case of loosening a large block of the load from the system there would be danger of the hydro units increasing in speed and causing the steam units to speed up to where the over-speed trip would operate and shut the units down, causing considerable inconvenience to the system. There was also the danger of the hydro units running away and increasing the frequency of the system to where the motors on the industrial loads would damage the machines they were driving due to over speed, or cause damage to the product being manufactured.

Efficient Operation

Efficient operation of hydro-electric plants hit a responsive chord. It was brought out that at Niagara Falls high efficiency is probably of greater importance than anywhere in the country. In the lower river there is considerable variation in tail-water level, but notwithstanding this handicap over 88 per cent of the total energy in the water, represented by the difference in levels between the upper river at the intake to the canal and tunnel and the lower river, is accounted for on the busbars.

The over-all efficiency of any installation will vary with the head length of waterway and other factors. In low-head installation the turbine casing losses may amount to several per cent of the total power developed by the unit where in a high-head installation this loss would represent an almost negligible quantity, but the waterway losses might be several per cent where canals, pipe line or tunnels are long.

Reducing the cost of power, it was pointed out, was of even greater importance than increasing the efficiency of plant unless this efficiency contributed toward reducing the power cost. If the expensive power house could be eliminated, it would do more toward reducing the cost of power than several points increase in efficiency. It was considered the ceiling in turbine efficiency had about been reached and that attention should be directed toward reducing the cost of the installation.

Modern Types of Draft Tubes

Objections were raised to the use of some of the modern types of draft tubes on account of their cost. Attention was called to the satisfactory results being obtained with bent draft tubes in Europe, and the question was raised as to the possibility of going back to this type of tube in this country. In answer to this it was stated that with low specific speed wheels it was possible to obtain satisfactory results with a bent type of draft tubes, but with high speed units this was not so. Attention was called to the difficulty that builders had in making their high-speed turbines meet their guarantees with the bent type of draft tube, before the development of the modern efficient types. Since the development of the highly efficient tubes these difficulties have been practically eliminated.

As to the cost of the modern draft tube, this, it was stated, had been greatly reduced by various means and in some cases the highly efficient tubes did not cost any more than the bent type. In one installation where a plate steel lining was used in the tubes it was estimated that the cost had been reduced 30 per cent over what it would have been if wooden forms had been used. It was said that at Niagara Falls they had gone into the cost of draft tubes very carefully, and these engineers were sure that the installation of the hydraucone and the spreading type of tube were justified from every consideration.

Power-Factor Correction*

By L. W. W. Morrow †

THE effects of low power factor on the operations of the electrical industry have been discussed for many years and much experience in the institution of corrective measures has been had. Yet on an industry-wide scale the evils associated with low-power-factor conditions become greater each year, even though the incentives for the institution of corrective measures increase. Low power factor has come to be recognized as the major handicap to better and more efficient electric service, and men of the industry are striving actively for a commercial and engineering method for its correction.

High Power Factor Operation Improves Service

An analysis of the data and experiences of those properties which have instituted power-factor correction leads to the conclusion that operation under high-power-factor conditions improves both the quality and the efficiency of the service rendered by the utilities and used by their customers. Correction of power factor has its greatest influence in improving the voltage regulation and through this action enables the utility to give better service and the customers to secure better use of the service. Secondary gains resulting from power-factor correction consist of the release of system capacity with a consequent reduction in investment and a reduction in system losses with a resultant reduction in operating charges. Thus correction tunes the system and makes it cheaper and easier to give service of the quality desired in modern industry.

Actual experience shows that power-factor correction can be instituted successfully as a part of the business activities of light and power companies and as a part of the normal operating activities of industrial users of electricity. It does not require an elaborate or costly departure from customary business activities, and it secures returns to the producer and the user the value of which is tangible and worth while. Yet little actual progress in power-factor correction can be seen because of many obstacles, mostly imaginary, set up in the minds of executives and customers.

The fact is that many properties have instituted correction successfully and made it a profitable part of their business. They have done this without any difficulty and did not find any great complexity or major changes introduced in their operating routine. Thus the time is ripe and the methods are available for eliminating low-power-factor conditions in the electrical industry. The rewards are ample, and the necessity for this move becomes greater with the growth of electrical systems.

Locations for Corrective Equipment

A study to determine the locations in which to install corrective equipment on existing systems shows that the decision is somewhat influenced by the type of system and by local conditions. Usually, corrective equipment should be located at all low-power-factor loads, in some cases at substations at a distance from generating stations, particularly if voltage regulation is desirable, and in very few instances in generating stations. The source of low power factor is at the load, and analyses will show that corrective equipment is best and most economically used in this location.

Consumer Correction

The analysis for determining the proper location of corrective equipment leads inevitably to the conclusion that most of it should be placed on the premises of consumers and that consumers using high-power-factor equipment are operating most economically from their own viewpoint and from that of the central station. From the angle of the central-station consumer, correction relieves the system of the necessity for correction at other locations, releases the transformer and cable capacity where it is most valuable from income and load-factor viewpoints, reduces losses where they are greatest and improves regulation where it is most desirable to have good regulation.

From the angle of the consumer correction of his equipment or the replacement of low-power-factor equipment with high-power-factor equipment will secure several tangible and intangible results. It will reduce the losses inside his premises, for which he pays a high rate; it will improve his voltage regulation and reduce his voltage drop, so that his machinery will operate faster and more smoothly; it will give him better-quality production, better lighting, fewer rejections of manufactured product, faster machine-starting conditions and secure for him a direct decrease in his power bill if he buys under a proper rate system.

Experience shows that operating complexity is not increased and that the industrial plant corrected for bad power-factor conditions reaps decided tangible and intangible benefits. Needless to say, it is useless to attempt an itemized cost evaluation for correction at load locations, because the complexity of modern distribution systems, the variety of loads and services and the many assumptions necessarily made all combine to give inaccurate results. In a broad way, however, based on the actual cost of the distribution system, the cost of voltage regulation and the cost of losses, an analysis in dollars will show decided inducements for investing power-factor correction at the source.

Kinds of Corrective Equipment

The corrective equipment to install at locations decided upon is determined largely by each local situation, but there are applications for all available types of low-power-factor loads; such as:

(a) The synchronous motor.
(b) The synchronous condenser.
(c) The high-power-factor commutating motor.
(d) The static condenser.

Investment charges on existing installations, production requirements, fixed and operating charges on corrective equipment and the skill required to operate the equipment influence the decision to be made for each load considered.

Power-Factor Rates That Have Been Used Successfully

The ultimate approach to power-factor correction for customers is by means of rate making. This has generally taken the form of:

(a) The use of power-factor clauses.
(b) The use of kva.-demand clauses.
(c) The use of kva.-hr. clauses.
(d) A combination of two of the foregoing.

All these methods have been used and all have worked more or less successfully, but all are subject to definite criticisms. Years of effort proved the impossibility of developing utility rates on a cost-of-service basis, and, however reluctantly, rate makers have admitted its impossibility and impracticability for modern conditions of utility service. No cost-of-service basis can be found, therefore, for the making of any type of power-factor rate, and each property must evolve a rate that can be instituted and operated to suit conditions encountered. A fundamental in power-factor rate making would be to secure a simple rate, one that could be applied to all customers, one that needed little maintenance or supervision and one that offered a financial inducement to customers to maintain and correct power-factor conditions.

Every type of power-factor rate has been used successfully, so the necessity of a rate to secure power-factor correction is not a real obstacle to the institution of correction. It must be remembered that grand average results only are to be expected and that precision methods and analyses must be modified by commercial considerations of each power system.

*Abstract from a paper presented at Regional Meeting, District No. 2, American Institute of Electrical Engineers, Washington, D. C., Jan. 23-24, 1925.

†Managing editor, *Electrical World*.

Water Power in the Madison River Basin, Mont.

A Geological Survey report "Water Power and Irrigation in the Madison River Basin," by John F. Deeds and Walter N. White, is a recently completed study of the utilization of the water of Madison River, Montana, which shows that its annual flow amounts to more than 1,400,000 acre-feet and that the topographic conditions along the river permit the utilization of a large part of this water for the development of hydro-electric energy and irrigation.

The water power available is now partly developed by plants having an installed capacity of 18,000 hp. and by storage reservoirs having a total capacity of 386,000 acre-feet. The undeveloped power resources on the river amount to about 136,000 hp. These estimates do not include power resources in Yellowstone National Park, where development is prohibited.—Published as Water-Supply Paper 560-A, Government Printing Office, Washington, D. C.

Colorado River Compact Rejected by Arizona

A resolution proposing ratification of the Colorado River Compact as accepted by the six other basin states has been defeated by a vote of 11 to 7 in the Senate of Arizona Legislature. With the defeat of the resolution three others were withdrawn and a resolution already adopted by the House of Representatives was taken under consideration. The resolution as passed by the House provides for ratification of the compact if representatives of Arizona, California and Nevada can agree to a distribution of the water allotted to the lower basin that will be acceptable to a special session of the Arizona Legislature.

According to recent press reports a resolution is to be presented to the Assembly of the California Legislature for the purpose of ratifying the Colorado River Compact between the six states favoring it with Arizona left out. Ralph E. Swing, state Senator from San Bernardino County, will pilot the bill in the Senate it is understood. The resolution is to be similar to those introduced in the Legislatures of Colorado and Wyoming and will clear the way for a pact among California, Colorado, Nevada, New Mexico, Utah and Wyoming.

Associated Gas Acquires New York Plants

Small utility companies which have operated in Ridgefield, Conn., and Katonah, Bedford, Croton Falls, Mahopac, Brewster, Cornell, Pawling, Wingdale, Dover Plains, Amenia, Copake and Chatham, N. Y., serving about eight thousand customers near the Connecticut and Massachusetts border, have been acquired by interests affiliated with the Associated Gas & Electric Co., New York, and permission has been asked of the Public Service Commission to group them in a compact operating company to be known as the Harlem Valley Electric Corp., with headquarters at Brewster. They will be connected by transmission lines.

The same interests have acquired in the western part of the state adjacent to Buffalo the Depew & Lancaster Light, Power & Conduit Co. and the electric system formerly owned by the Iroquois Utilities Co., serving about 10,000 consumers from Clarence, east of Niagara Falls, south to Depew, Lancaster and East Aurora, and through the territory to the Iroquois Utilities Co., which includes Gowanda, Randolph and other localities. Application has been made to authorize the Depew & Lancaster company to acquire the property of the Iroquois Utilities Co.

No Material Progress Made on G. E. Investigation

In conformity with the mandate of the Senate the Federal Trade Commission has begun work on the investigation of the General Electric Company, but no great amount of progress can be made until after June 30. The small staff of the Economic Division has about all it can do to complete other reports which must be in finished form prior to the end of the fiscal year. The report on the General Electric Co. is not required until Dec. 7, the date on which the next regular session of Congress will convene.

Wage Revision in Bituminous Field Being Discussed

As the bituminous coal operators in the union fields are formulating their policies looking to wage revision, the hope is expressed in official quarters in Washington that no resort will be had to force in the attempt to secure a reduction. It is held to be obviously the best course for the operators to wait if they cannot obtain wage concessions by persuasion. Time will fight on their side.

Economic forces already have accomplished more toward convincing the United Mine Workers of the need of an adjustment than did the direct assault in 1922. A demand for a reduction then precipitated a great strike and gave the United Mine Workers another chance to demonstrate its extraordinary qualities as a fighting organization. Some contend, of course, that the mine workers would have lost in 1922 had they not been helped out by the railroad shopmen, and by the Administration, but that is not the point. Either through luck or by sheer staying power the organization always has won in a contest of force. The whole tradition and the whole discipline of the organization fit in around the idea of striking.

If the operators now force a break, it is entirely clear that it will arouse the war spirit of the mine workers. It would halt abruptly the drift away from the union under the pressure of unemployment.

Signs are multiplying even among the union men in the borderland districts, which indicate that the Jacksonville agreement is unworkable. The same week that brought official denial from the international president of any cuts in the Fairmont district, brought newspaper accounts from Central Pennsylvania to the effect that union men are mining 2,400 lb. for the nominal price applying to 2,000 lb. and are putting in additional time for which they receive no pay.

Shoals Commission Members Probably Named Soon

The President is expected to name promptly a commission to make recommendations as to future operations at Muscle Shoals. Since there is a balance of $150,000 remaining of the appropriation in the National Defense Act, this amount will be available for the prosecution of the study. Recommendations for the technical member of the commission are being considered by Commerce Secretary Hoover. An effort also is being made to secure the appointment of an electrical engineer to the commission. It is possible that the President may enlarge the commission to five members, but even should only three members be appointed, it is pointed out, an electrical engineer could be found who would qualify as "a representative citizen familiar with the Muscle Shoals enterprise."

The Administration is understood to be particularly desirous of securing a commission of outstanding men who have not been active participants in any of the controversies that have raged around Muscle Shoals. This has eliminated some of the men who have a very comprehensive knowledge of the situation.

Snake River Has Large Power Possibilities

In connection with a survey made along Snake River, by the Geological Survey, from Lewiston, Idaho, to Huntington, Ore., a study of the possible water-power sites was made by W. G. Hoyt, who found fifteen undeveloped power sites at which, with the present flow, 1,430,000 hp. can be developed for 50 per cent of the time and 861,000 hp. for 90 per cent of the time. With regulated flow and complete irrigation development 1,080,000 hp. can be developed for 50 per cent of the time and 750,000 hp. for 90 per cent.

One of the projects considered includes a diversion dam on Salmon River, a tunnel to Snake River and a dam 530 ft. high on Snake River. As this project would make possible the development at one plant of 910,000 hp. for 50 per cent of the time and 636,000 hp. for 90 per cent of the time, the site is one of the largest yet undeveloped in the country. A trunk line extending between Salt Lake City and Spokane, which would radiate power eastward to the Mississippi Valley and westward to the Pacific Coast, is suggested by the surveyors. The only development yet made in this stretch of the river is a 12,400-hp. plant near Copperfield, Ore.—Published as Water-Supply Paper 520-C. Government Printing Office, Washington, D. C.

Interstate Public Service's Construction Program

More than $2,000,000 is to be spent during the current year by the Interstate Public Service Co., Indianapolis, operating electric power, light and interurban services in Indiana, in improvements and betterments to its power production and distribution units, according to Harry Reid, president of the company. Included in this program are the installation of a 10,000-kw. steam turbine at the Edwardsport plant of the Indiana Power Co., a subsidiary organization, and the construction of a 60,000-volt outdoor substation and other equipment to make this plant a modern producing unit. The two hydro-electric generating plants near Goshen, Ind., on the Tippecanoe River are to be started as soon as possible and will cost nearly $500,000.

Transmission lines are to be constructed to nearby municipalities.

Sydney, Australia, Seeking New Power Sources

In Sydney, New South Wales, Australia, electricity is supplied to the Metropolitan area by the Sydney City Council, the Railway Commission and the Electric Light & Power Supply Corp., Balmain. Aside from five suburbs the rest of the area is supplied by the City Council and Railroad Commission. The electricity is generated in this latter area at three power houses, Ultimo and White Bay, which belongs to the Railroad Commission, and Pyrmont, belonging to the City Council, according to press dispatches.

The White Bay site is the only one of the three not fully developed. It is suitable for the development of an additional 120,000 hp. which will provide sufficient electricity in the Metropolitan area up to the year 1929 or 1930. For additional supplies required after that date a new source must be found.

It is the opinion of the officials of the Railway Commission and the City Council that immediate steps should be taken to select a site for a power house, on a very large scale, on or near a large coal field. The site must be on the ocean or an inlet of the ocean and near enough to Sydney to make the transmission of current practical. It is believed that the coal field on the south coast would meet these requirements. The Royal Commissioners who recently carried out an investigation of the Railway Department for the New South Wales Government, Sir Sam Fay and Sir Vincent Raven, advocated in their official report the desirability of proceeding immediately with the establishment of a large power house on the south coast. A recent visit was made to possible sites on the south coast by the officials, accompanied by Mr. Pearce, the English expert who has been investigating the City Council's electricity department, recently.

According to *Commerce Reports* leather is the most popular belting material used in Italian industries, supplying about 80 per cent of the demand. Approximately 50 per cent of the total amount needed is obtained from foreign sources.

Basle-Strasburg Canal to Develop 785,000 Hp.

The project for the construction of a canal alongside the Rhine, which is to facilitate navigation between Basle and Strasburg and will permit of the laying down of hydro-electric installations capable of producing an average total of 785,000 hp., has made a step in advance by the Swiss authorities sanctioning the first stage of the undertaking between the frontier and Kembs, according to *The Engineer*. This sanction has been obtained only after long and arduous negotiations, owing to the proposed barrage raising the high-water level of the Rhine as far as Basle.

The scheme consists in the construction of a barrage across the Rhine about 3½ miles from the Swiss frontier. It will raise the low-water level by 26 ft. and the high-water level by 13 ft. The barrage will be constructed of piers with Stoney superimposed sluice gates, the width of the central openings being 98 ft. and of the end openings 58 ft. The canal will start from the Rhine about 1,600 ft. above the barrage and will have a length of a little more than 3½ miles. It will have a width of more than 400 ft. The volume of water passing through the canal will, of course be regulated by the barrage, sluice gates and by the requirements of the turbines.

The Francis turbines are of the vertical type, each of about 12,000 hp. In the event of a turbine stopping, a sluice gate will open automatically to allow the passage of a corresponding volume of water. By the side of the generating station a lock 610 ft. long and 82 ft. wide is to be constructed, and if that be found insufficient for the traffic, a second lock 330 ft. long will be made. From here the canal bends around and falls into the Rhine. The average head of water at the turbines during ten months of the year is 43 ft., and the energy produced will be an average of about 12,000 hp.

This section will constitute the first part of the Alsace Canal, which will be composed of seven similar sections each, with a hydro-electric installation and each flowing into the Rhine through a short bend, so that as each section is completed it will be put into service while the remaining part of the waterway is being constructed. The total length of the canal will be 60 miles or 4¼ miles shorter than the river.

At the first three generating stations at Kembs, Ottmarsheim and Fessenheim the head of water at the turbines will be from 43 ft. to 46 ft., at Vogelgrun, Markilsheim and Sundhouse it will be from 43 ft. to 46 ft., at Vogel-Gertsheim and Strasburg the head will be 36 ft. The supply from all the stations, which will, it is estimated, amount to some 785,000 hp. will be connected up with the general distribution scheme in the northeastern departments of France.

Standardization of Valves Postponed by A.E.S.C.

The American Engineering Standards Committee announces that it has decided to postpone indefinitely the conference on the standardization of valves which has been under discussion during the last two years. The postponement is taken as the result of a request to this effect by the Manufacturers Standardization Society of the Valves and Fittings Industry.

The action in postponing the conference is in accordance with the announced policy of the A.E.S.C. that it will not act as an initiating body, and that it undertakes work on a project only upon a formal request by a responsible body and after investigation as to the desirability of the work by the A.E.S.C.

Dutch East Indies Buys Power Machinery

Exports of power-generating machinery, except electric, to Dutch East Indies, gained from $31,033 in 1922 to $66,120 in 1923, according to *Commerce Reports*.

Exports of this group for the first six months of 1924 have exceeded the 1923 figure. A considerable increase occurred in shipments of internal-combustion engines for 1924, which amounted to $22,536 during January to June, inclusive, of this year, and only $2,820 in all of 1923. An expanding market for motive power equipment, especially in the gas-engine field, is indicated. The following table gives American exports of power generating machinery, except electric, to the Dutch East Indies for 1922, 1923, and for the first six months of 1924:

UNITED STATES EXPORTS OF POWER-GENERATING (EXCEPT) ELECTRIC MACHINERY TO DUTCH EAST INDIES

Class	1922	1923	January-June, 1924
Steam engines:			
Stationary, except turbines	.....	$7,046	$15,006
Other engines, accessories and parts	$6,638	$29,027	9,806
Boilers	.....	1,178	.....
Condensers, heaters, and accessories	.....	330	.....
Injectors, gages, safety valves, and other boiler accessories and parts	1,535	10,784	3,393
Internal-combustion engines:			
Stationary and portable engines—			
Diesel and semi-Diesel	724	615	.....
Other stationary, over 8 horsepower	2,848	2,205	22,536
Marine engines—			
Diesel and semi-Diesel	.....	47	5,295
Other marine, except detachable marine engines	6,377	1,404	323
Engine accessories and parts for	12,911	13,484	10,146
Total	31,033	66,120	66,535

UNITED STATES EXPORTS OF PUMPING MACHINERY TO THE DUTCH EAST INDIES

Class	1922	1923	January-June, 1924
Pumps:			
Centrifugal pumps	1,232	.....	.....
Steam pumps	14,297	2,405	14,217
Other pumps and pumping machinery	20,504	12,955	61,281

John Fritz Gold Medal to Be Presented to J. F. Stevens

The John Fritz Medal Board, representing the A. S. C. E., A. I. M. & M. E., A. S. M. E. and A. I. E. E., will present with suitable ceremony the John Fritz Gold Medal to John Frank Stevens at a meeting to be held in the auditorium of the Engineering Building, 29 West 39th St., on March 23. The speakers will be Ralph Budd, president of the Great Northern Railway Co., who will speak on Mr. Stevens as engineer in planning and organizing for the construction of the Panama Canal, and Honorable Roland S. Morris, formerly Ambassador to Japan, who will talk of Mr. Stevens as administrator of the Chinese & Siberian Railway.

This is an open meeting and all friends and engineers, including ladies, are invited to attend.

Ohio River Ferryboat to Be Equipped with Diesels

The "W. S. McChesney, Jr.," a side-wheel ferryboat owned by the Falls Cities Ferry & Transportation Co., of Jeffersonville, Ind., is to be equipped with Diesel-electric propulsion equipment.

The boat has been in passenger and freight service between Louisville, Ky., and Jeffersonville, Ind., on the Ohio River since 1912, using reciprocating engines for motive power. The new equipment will consist of two Fairbanks-Morse Diesel engines, direct-connected to two 175-kw., 230-volt, d.c. generators. Power from the generators will be used in driving two 180-hp. motors, running at 425 r.p.m. at full speed. Through a system of double reduction gears the motors will be connected to the two paddlewheels, turning at 14 r.p.m. The main generators will also supply power for the illumination of the boat and for running the boat's auxiliaries. All the electric equipment will be of General Electric manufacture.

Economy is the outstanding advantage claimed for the new type of propulsion. By operating with less fuel, more trips can be made without refueling and there should be no stand-by losses such as are experienced by steam vessels when docking or idle. The electric drive is also expected to afford greater flexibility in maneuvering and a higher average ship's speed. Absence of cinders and dust is also an advantage of the use of Diesel-electric propulsion equipment.

A single generator only will be needed for running the boats at low speeds. Further economies are expected from this. By the use of but one generator, approximately 75 per cent of full speed can be attained, the current from the one machine being used to operate both propelling motors.

The boat, with its new electric drive, is expected to go into service by May 1, 1925.

Construction of Hydro Plant To Be Started in Ceylon

Construction work is about to be started on the hydro-electric scheme which will supply not only Colombo, but a considerable portion of the Island of Ceylon with light and power, according to government reports.

Exports of Leather Belting Show Increase

The United States exported 100,578 lb. of leather belting, valued at $159,497, to foreign countries during January, 1925, an increase of 40.9 per cent over the quantity exported during the first month of 1924. Important markets contributing to this increase and the amounts received during January, 1924 and 1925, respectively, were as follows: Cuba, 8,811 and 20,042 lb.; Mexico, 1,993 and 13,724 lb.; British India, 3,919 and 13,639 lb.; South America, 15,463 and 17,933 lb.; and the United Kingdom, 1,202 and 6,548 lb. There was a slight decrease in the shipments to Canada (7,877 and 5,731 lb.), and larger decreases in the quantities shipped to China (14,831 and 6,243 lb.), and to Japan (6,210 and 575 pounds).

Mid-West Power Show's Success Predicted

Reports from the officers of the Mid-West Power Show, which is to be held in the auditorium at Milwaukee, May 18-21, indicate that this exhibition of mechanical equipment will be a decided success. Contracts for space have been coming in in a gratifying manner, although there is still space available. The building is admirably adapted for the purpose, and plans are being made to extend every possible courtesy to the exhibitors.

During the same week there will be large delegations of engineers in the city attending three engineering conventions. It will be recalled that the American Society of Mechanical Engineers is to hold its spring meeting in Milwaukee during this period, also the American Society of Refrigerating Engineers and the Wisconsin State Association of the National Association of Stationary Engineers will hold its annual convention there. With Milwaukee a large industrial center and engineers of all classes participating in the events of the week, a large attendance is assured.

France Buys American Power Machinery

Sales of American industrial machinery to France during the first nine months of 1924, according to *Commerce Reports*, increased approximately 10 per cent over the corresponding period of 1923. An increase of 43 per cent occurred in exports of power-generating machinery (omitting electric) as shown in following table:

UNITED STATES EXPORTS OF INDUSTRIAL MACHINERY TO FRANCE

Class	1922	1923	January to September, 1923	1924
Power generating machinery, except electric	$321,498	$311,372	$215,988	$309,135
Construction and conveying machinery	153,836	230,997	138,171	136,275
Mining, oil-well, and pumping machinery	528,714	830,949	777,389	582,646

Three Men Killed at Colfax Station

An unfortunate accident, inexplainable except in the light of human fallibility, resulted in the death of three men at the Colfax Station of the Duquesne Light Co. on the morning of Feb. 25.

All three men were employees of the Westinghouse Co., and one, a man of long experience, had been engaged in work around this station for three or four years. They were repairing an oil switch on the station bus, adjacent to but separated physically, both by compartment walls and a passage, from one of the 12,000-volt main generator oil switches, which was open but whose disconnects were closed.

All the usual precautions had been taken in clearing the switch upon which they were working by opening the disconnects and proper tagging, and in fact one of the station operators had observed the men working on the station bus switch a short time previous to the accident. For some unknown reason the men left the dead switch upon which they had been working and proceeded to take down the adjacent generator switch. After removing the compartment door they had removed the oil pot on one of the phases of the open switch, and in attempting to remove the second pot the short-circuit occurred. All three were fatally burned and died shortly after without being able to make any statement.

It might be pointed out that one of the additional precautions taken in this station is the employment of a key to the disconnecting switch compartment, this key being kept in a locked receptacle in the oil switch compartment and can be obtained only when the oil switch is opened. This is to prevent attendants from opening the disconnecting switches before the oil switch is opened. The men were familiar with this practice, but the fact that the key was found in place showed that they had not taken the usual precaution of ascertaining whether the disconnects were open.

Why the men should shift from the switch upon which they had been working to the second switch will probably never be known.

Three 20,000-kw. generators fed directly into the short and four other generators through transformers. Even under these severe conditions the short-circuit and fire was limited to one compartment, emphasizing the value of separating walls, barriers, fireproof cell doors, etc., as a safeguard in the design of the station. There was no contagion of the trouble. The building was only slightly damaged, but because of the explosion and the dense smoke in the switchroom, caused by the burning oil, the operators very properly shut down the plant in order to rescue the men and avoid the possibility of further damage. The shutdown resulted in the temporary loss of about 150,000 kw. of power.

Although one of the generators was damaged as a result of the short-circuit, the fact that the station is part of an interconnected system enabled the load to be picked up as soon as the various circuits could be restored.

Franklin Union To Open On March 23 for Inspection

On Monday evening, March 23, the Franklin Union, a technical institute, of Boston, Mass., will award certificates, record and pass cards to evening students in engineering and technical subjects. After the presentation of certificates the classrooms will be open for inspection, giving the public a chance to see the work which has been accomplished by the 1,600 students attending the school this past winter.

Engineers Wanted by U. S. Government

The United States Civil Service Commission, Washington, D. C., announces examination for civil engineer, salary $3,800; associate engineer, civil, electrical, mechanical, signal, $3,000; assistant engineer, civil, electrical, mechanical, signal, at $2,400. Receipt of applications will close April 4.

The commission also announces an examination for junior engineers at an entrance salary of $1,860. Applications must be received before March 28.

Conowingo Project Attacked by Rapid Transit Co.

The filing of five applications with the Pennsylvania Public Service Commission by the Philadelphia Electric Co. and the Susquehanna Power Co., asking the approval of their development plans for the Conowingo (Md.) hydro-electric project, estimated to cost $52,000,000, has brought an unexpected attack on the whole undertaking from the Philadelphia Rapid Transit Co.

The basis for this attack is the assertion that the Rapid Transit Co. uses about 20 per cent of the output of the Philadelphia Electric Co. in the operation of the street-railway system of the city and that this amounts to two-thirds of the energy used by the Transit system. The Rapid Transit Co. maintains, in briefs filed March 9 and 10, that the present rates of the Philadelphia Electric Co. are excessive and discriminatory and asks for a reduction. Other contentions are that the Electric Co. is to pay an excessive price to Drexel & Co. for the site and that Stone & Webster will make excessive profits on the construction of the project.

Request is made for an audit of the power company's books, covering aspects of the business, its production and operating costs. The brief says that these data are "necessary to permit the Philadelphia Rapid Transit Co. to check estimate of savings of $800,000 per annum due to the introduction of Conowingo power."

Hearings are to be held by the Pennsylvania Public Service Commission on March 27 at Philadelphia. At this hearing the Maryland Public Service Commission and a representative of the Federal Power Commission will sit with the Pennsylvania Commission.

One aspect of the complicated situation is that presented by the attitude of the State of Maryland and individual citizens and associations who oppose the project. Governor Ritchie of Maryland has drawn up reservations to protect the state's rights.

Hearings on Colorado Basin Scheduled for Summer

A resolution has been passed authorizing the Senate Committee on Irrigation and Reclamation "to make a complete investigation with respect to proposed legislation relating to the protection and development of the Colorado Basin." The committee, or any subcommittee thereof, is authorized to hold hearings at any point within the United States prior to the opening of the first regular session of the next Congress. Senator McNary of Oregon is the chairman of the committee and will preside at the hearings.

World's Petroleum Estimated for 1924

The American Petroleum Institute estimates the world's petroleum production in 1924 at 1,013,139,000 bbl., compared with 1,018,900,000 bbl. reported by the U. S. Geological Survey for 1923, a decrease of 5,761,000 bbl., or 0.6 per cent.

ESTIMATED WORLD PETROLEUM PRODUCTION

	1924		*1923	
	Barrels	Per Cent of Total	Barrels	Per Cent of Total
United States	714,000,000	70.5	732,407,000	71.9
Mexico	139,587,000	13.8	149,585,000	14.7
Russia	45,162,000	4.4	39,156,000	3.8
Persia	31,845,000	3.1	28,793,000	2.8
Dutch East Indies	21,000,000	2.1	19,868,000	1.9
Rumania	13,296,000	1.3	10,867,000	1.1
Venezuela	9,500,000	.9	4,059,000	.4
India	8,150,000	.8	8,320,000	.8
Peru	7,812,000	.8	5,699,000	.6
Poland (Galicia)	5,710,000	.6	5,373,000	.5
Sarawak (Br. Borneo)	4,500,000	.4	3,940,000	.4
Trinidad	4,284,000	.4	3,051,000	.3
Argentina	3,844,000	.4	3,400,000	.3
Japan	1,600,000	.2	1,789,000	.2
Egypt	1,107,000	.1	1,054,000	.1
Colombia	500,000		424,000	
France (Alsace)	436,000		403,000	
Germany	350,000		312,000	
Canada	175,000		170,000	
Czechoslovakia	100,000	.2	74,000	.2
Italy	33,000		34,000	
Algeria	14,000		9,000	
Cuba	4,000		4,000	
Others	130,000		109,000	
Total	1,013,139,000	100.0	1,018,900,000	100.0

* Figures for 1923 are those of the U. S. Geological Survey.

Method of Treating Lignite Discovered by Dr. Schoch

After a series of tests and experiments covering a number of years, Dr. E. P. Schoch, professor of physical chemistry, University of Texas, has discovered a method of treating lignite by which 30 per cent of its orignal 35 per cent of moisture content is extracted and about 5 per cent of heavy fuel oil is added, giving a pound of the dry fuel a heating power approximately 50 per cent greater than a pound of raw lignite. Dr. Schoch says that the total cost of the treated lignite at the mine, including the expense of the dehydrating process, is $2.51 a ton.

"Dehydrated lignite stores well and can be fired easily," according to Dr. Schoch. "It will actually cost less than the cheapest raw lignite ever furnished, while the latter cannot be stored and is much more troublesome to handle."

Describing his process of treating lignite, Dr. Schoch said: "The raw lignite is dumped into a container with a perforated bottom and this is placed in a retort with a tight-fitting lid, a bottom connection to admit the oil, and an upper outflow connection. Cool petroleum oil, composed of about 75 per cent gas oil and 25 per cent of heavy fuel oil, is pumped into the bottom of the retort and passes upward through the lignite, overflowing into a large flat vessel where the oil foam separates into steam and oil. From this 'defoamer' the vapors pass to a condenser while the oil drops down in the circulating pump, by which it is driven through pipe coils in a furnace and then returned to the bottom of the retort holding the lignite. The oil is gradually heated up until a temperature of 570 deg. F. is reached in about three hours. During this operation the water is steamed out of the lignite and it, together with some of the oil vapors, is condensed to regain the vaporized oil. When the stated temperature has been reached, the oil is drained completely out of the bottom of the retort, and superheated steam is blown through the lignite to vaporize the light oil absorbed by the latter. By this means the only oil remaining in the lignite will be heavy fuel oil, which will amount to about 5 per cent of the weight of the dehydrated lignite. This remnant oil serves mainly to 'film' the pores in the lignite, so that it will not reabsorb moisture nor react with air. It does not serve as a binder.

"To cool the charge, some ordinary steam is blown through it until the temperature has dropped to about 300 deg. F. and then a shower of cold water is poured over it. The lid of the retort is then removed and the lignite container with its charge is lifted out, more water poured over the lignite until it is cooled below 150 deg. F. and then the charge is dumped. The whole operation lasts only about four hours."

It is stated by Dr. Schoch that Texas has about twenty-two billion tons of lignite in sight and probably more to be revealed by future exploration.

Engineers Must Be Licensed in Washington

Despite objections on the part of the Commissioners of the District of Columbia, the President signed the bill requiring operators of engines generally to be licensed. This bill was outlined at greater length in Feb. 17 *Power*, page 280. Prior to the enactment of this law compulsory licensing in the District of Columbia applied only to those operating steam engines. The former statute had been enacted in 1887 before internal-combustion engines were in use.

The District Commissioners at first recommended favorable action on the bill. On giving the matter further study, however, they reached the conclusion that the language of the bill was too broad and might be construed to include operators of automobile engines or other small engines.

The International Steam and Operating Engineers' Association urged the President to sign the bill. The representative of the organization declared that the Commissioners had been influenced by building contractors who were opposed to the measure.

Stanford Buys New Testing Outfit

Leland Stanford University, Palo Alto, Calif., has recently ordered a General Electric 2,000,000-volt testing outfit. This set will operate at 60 cycles and will jump a spark gap formed by two needles about 17 ft. apart. The new apparatus will be located in a special laboratory with ample ground plot for an experimental transmission line. Prof. Harris J. Ryan, past-president of the A.I.E.E. and an authority on high-tension phenomena, will in the future devote his entire time to research in this high-voltage field.

Yale Professors To Improve Rescue Inhalator

The daily press announces, that Professor of Applied Physiology, Dr. Yandell Henderson with Prof. H. W. Haggard, of Yale University, are perfecting their inhalator which is expected to reduce the death rate from carbon monoxide, electric shock and other forms of asphyxiation, and drowning.

Pending experiments the nature of the improvement will not be disclosed. Dr. Henderson stated, however, that in cases of asphyxiation involving complete cessation of breathing, the manual prone pressure method of resuscitation should be used in preference to any other. He urged that all persons using electricity learn to use this method.

Personal Mention

F. T. M. Kissel, assistant electrical engineer to the government of New Zealand, has been appointed chief electrical engineer to succeed the late Lawrence Birks.

H. C. Acres, formerly chief hydraulic engineer of the Ontario Hydro-Electric Power Commission, has been elected a member of the board of governors of the University of Toronto.

Charles Walsh, formerly chief engineer of the Feneway Hall Hotel, has been appointed chief engineer of the new power plant of the Western Reserve University, of Cleveland, Ohio.

Edward D. P. Gross, has been appointed power engineer of the Hartford (Conn.) Electric Light Co., succeeding H. W. Derry. Mr. Gross is a graduate of the Rensselaer Polytechnic Institute, class of 1913, and has been with the Hartford company for the past three and one-half years in generating-plant work.

Society Affairs

The San Francisco Section of the A.S.M.E. will have as the subject of its March 26 meeting, "Hydraulic Machinery," E. C. Hutchinson, of Toledo.

The Metropolitan Section of the A.S.M.E. together with the A.I.E.E., A.S.C.E., A.I.M. & M.E. and the New York Electrical Society, will hold a joint meeting on March 18, at the Engineering Building, New York City,. Julius Kruttschnitt, of the Southern Pacific, and Samuel Vauclain, of the Baldwin Locomotive Works, will speak on "The Engineer as an Executive."

The Erie Section of the A. S. M. E. will have as the attraction for its March 24 meeting, "Modernization of Industrial Power Plants," by Egbert Douglas, Cahill & Douglas, Cincinnati.

The Boston Section of the A.S.M.E. will visit the plant of the Edison Illuminating Electric Co., Boston, from 1 to 6 p.m. on March 26. The subject of the meeting will be the new station, Weymouth.

The Metropolitan Section of the A. S. M. E., Power and Fuels Division, will hold a meeting at 29 West 39th St., New York City, on March 21. "Unit Systems of Burning Pulverized Coal," will be the subject, with representatives of various companies participating in the discussion.

The Indianapolis Section of the A.S.M.E. will hold a joint debate between the students of the Rose Polytechnic Institute and Purdue University on "Resolved, That the United States Should Favor the Building of a Great Lakes-St. Lawrence Waterway in Cooperation with Canada."

The American Society of Testing Materials, 29 West 39th St., New York City, has been invited by the United States Commission of the International Electrochemical Commission, upon which it is represented, to prepare a report on the testing of transformer oils for the use of the committee at the meeting of the International Commission at The Hague, Holland, next April.

The New York Chapter of the Heating and Ventilating Engineers will hold a meeting on Mar. 23, at the Building Trades Club, 34 West 33d St., New York City. "Heating and Ventilating Engineers and Their Human Relations" is to be the subject. The speakers will be LeRoy E. Kern, American Institute of Architects; C. T. Coley, Building Managers and Owners' Association; Stanley Ross, S. W. Straus Co.; Albert L. Baum, consulting engineer; Homer Addams, Kewanee Boiler Co.; J. I. Kyle, Carrier Engineering Corp.

Coming Conventions

American Association of Oil Burner Manufacturers. Leod D. Becker, Bank of Galesburg Bldg., Galesburg, Ill. Convention and exhibit at Edgewater Beach Hotel, Chicago, April 1-3.

American Electrochemical Society. Dr. Colin G. Fink, Columbia University, New York City. Convention at Niagara Falls, April 23-25.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Convention at St. Louis, April 13-17. Annual convention at Saratoga Springs, June 22-26.

American Society of Civil Engineers. George T. Seabury, 29 West 39th St., New York City. Spring meeting in Cincinnati, April 22-24.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

American Water Works Association. W. N. Niesley, 170 Broadway, New York City. Convention at Louisville, Apr. 27-May 3.

Canadian Association of Stationary Engineers. Geo. J. Soucy, 48 Moore Ave., Toronto, Ont., Secy. Convention at Windsor, June 29-July 1.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Convention at Hot Springs, Va., May 26-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th St., New York City, April 27 to May 2.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

Mid-West Power Show at Milwaukee, Wis., May 18-21. Ralph H. Cahill, care of Mid-West Power Show, City Hall, Milwaukee, Wis.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Indiana State Association** at Purdue University, Lafayette, Ind., April 20-23. W. C. Knowles, Northern Indiana Gas & Electric Co., Lafayette, Ind. **Kansas Association** at Topeka, May 6-8. J. M. Van Sant 739 Horne St., Topeka. **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **Wisconsin Association** at Milwaukee, May 18-22. F. W. Horn, 256 29th St., Milwaukee, Wis. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **Iowa State Association** at Ottumwa, June 16-18. F. L. Stocker, 127 S. Elm St., Ottumwa, Iowa. **New England States Association** at Worcester, Mass., July 10-12, formerly announced June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Michigan Association at Muskegon**, July 15-17. Charles Unterreiner, 5522 Underwood Ave., Detroit, Mich. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National District Heating Association. D. L. Gaskell, Greenville, Ohio. Sixteenth annual convention at West Baden Springs Hotel, West Baden, Ind., May 19-22.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

Business Notes

The Chicago Pneumatic Tool Co., Chicago, Ill., announces the opening of a branch office at 1a San Juan de Letran, 15 Mexico, D.F.

The Dean-Hill Pump Co., Anderson, Ind., announces that the plant of the Hill Pump and Turbine Works, formerly a division of the Midwest Engine Corp., has recently been acquired by them. The organization will remain unchanged. The new company will continue the manufacture of Hill pumps and Wait turbines.

The Reading Iron Co., Reading, Pa., announces that R. I. Fretz, formerly connected with the Bethlehem Steel Co. and the Midvale Steel & Ordnance Co., has been appointed to assume charge of marketing its boiler tubes; Allan M. Cullum has been appointed to the sales force for service in connection with the sale of wrought-iron pipe.

The Bundy Steam Trap Co., Nashua, N. H., announces the appointment of the George H. Alwine Co., Omaha, Neb., as its representative for eastern Nebraska and western Iowa; W. L. Sullivan, Machinery, Tulsa, for Oklahoma, northern Texas and southern Kansas.

The Diamond Power Specialty Corp., 10340 Oakland St., Detroit, Mich., announces that Lynn W. Nones has been appointed Eastern sales manager in charge of Atlantic Coast offices from Boston to Charlotte, and will have his headquarters at 90 West St., New York.

Barber-Greene Co., Aurora, Ill., manufacturers of material handling machines, has recently placed assistants in three of its district managers' offices. H. H. Driver will assist J. A. Gurney at Pittsburgh; Frank S. Howard, Jr. will assist E. D. Cassel at Cleveland; and P. S. Frederick will assist C. B. Gould at Detroit.

The C. J. Tagliabue Manufacturing Co., 18 Thirty-third St., Brooklyn, N. Y., announces changes in its organization, due to increased business. The engineering research department will be in charge of Victor Wichum, who continues as chief engineer; the development work will be carried on by Frank Bast in the experimental department; development of oil-testing instruments continues with R. M. Wilhelm, formerly with the Bureau of Standards, in charge; Daniel C. Day will work on problems of the users of the company's instruments under the general sales manager, Harvey D. Cooke; William C. Begeebing will head the division in charge of automatic controllers, dial indicating and recording thermometers.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	Mar. 9, 1925
Pool 1	New York	$2.50@$2.85
Smokeless	Boston	1.66
Clearfield	Boston	1.75@ 2.20
Somerset	Boston	1.90@ 2.35
Kanawha	Columbus	1.40@ 1.60
Hocking	Columbus	1.35@ 1.65
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.25@ 1.35
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.15@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.25@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1.	New York	$2.00@$3.15
Buckwheat No. 1.	Philadelphia	2.25@ 3.00
Birdseye	New York	1.35@ 1.60

FUEL OIL

New York—Mar. 12, light oil, tank-car lots; 28@34 deg. Baumé, 6½c. per gal.; 36@40 deg., 6¾c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Mar. 3, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 5.55c. per gal.; 38@40 deg., 6¼c. per gal.

Pittsburgh—Mar. 3, f.o.b. local refinery; 30@34 deg. fuel oil, 6½c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.

Dallas—Mar. 10, f.o.b. local refinery, 26@30 deg., $1.85 per bbl.

Philadelphia — Mar. 6, 28@30 deg., $2.73@$2.793 per bbl.; 18@22 deg., $2.42@$2.483; 13@16 deg., $2.10@$2.163 per bbl.

Boston—Mar. 9, tank-car lots, f.o.b.; heavy oil, 12@14 deg., Baumé, .048c. per gal.; light oil, 28@32 deg. Baumé, 6c. per gal.

Cincinnati — Mar. 9, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6¾c. per gal.; 30@32 deg., 7c. per gal.

Trade Catalogs

Instruments — Uehling Instrument Co., 473 Getty Ave., Patterson, N. J. Bulletin 118 describes the new Apex CO_2 pneumatic recording and indicating instrument.

Couplings—The Falk Corp., Milwaukee, Wis. Bulletin No. 35 describes the Falk-Bibby flexible couplings. Tables, drawings and photos, as well as good printing, add to the interest of the presentation.

Regulators, Combustion — Smoot Engineering Corp., 136 Liberty St., New York City. Bulletin 17, "Smoot Control," gives a description of the Sherman Creek type of Smoot control, illustrated with diagrams and photos of the regulators.

Stokers—Riley Stoker Corp., 9 Neponset St., Worcester, Mass. A neat catalog has recently been issued by this company, "A Type for Every Stoker Need," showing the Riley underfeed stoker, the Riley super-stoker, Jones "A-C", "Lateral retort" stoker, Jones "side-dump" stoker, Jones "Standard" stoker, "industrial furnace" stoker, Murphy furnace, the Harrington stoker.

New Plant Construction

Ala., Birmingham—Bessemer Ice & Coal Co. awarded contract for the construction of a 75 x 200 ft. electrically operated ice manufacturing plant, with capacity of 60 ton per day, to Holly & Davis, 4401 Comm. Ave., Ensley. $100,000. Owner is in the market for ice manufacturing machinery. G. Woodrow is manager.

Calif., Chino—Soper Bros., are in the market for a 20 to 24 in. centrifugal pump; 100-150-200 hp. steam engine; 200 hp. or two 100 to 125 hp. steam engines **(used)**.

Calif., Los Angeles—California Lutheran Hospital Assn., awarded contract for the construction of a 3-story hospital building on 15th St. near Hope, to the Los Angeles Planing Mill Co., 1812 Industrial St. $1,030,000. Steam heating system will be installed.

Conn., New Haven—New York Syndicate, c/o A. W. Sperry, Chapel St., Engr., plans the construction of an eleven-story hotel and theater building on George St. Estimated cost $1,000,000.

Conn., Putnam—Water Department will purchase motor-driven centrifugal pumps, 3,000,000 gal. per day capacity. Estimated cost $8,500.

Fla., Miami—C. H. Watson, 330 Third St. is having plans prepared for the construction of a 15-story hotel at Northeast Bay Shore and Second Ave. G. L. Preacher & Co., Healy Bldg., Atlanta, Ga., is engineer and architect.

Fla., Miami Beach (Miami P. O.)—Hotel Floridan Co., J. Cherbino, Pres., is having plans prepared for the construction of a 9-story hotel at 5th St. and Albion Rd. Estimated cost $750,000. A. D. Bullerworth, Miami Beach, is architect.

Fla., Sarasota—C. Ringling, et al, are having plans prepared for the construction of a 12-story hotel on Taniami St. between Trail and Ringling Blvd. Estimated cost $1,000,000. Pringle & Smith, Atlanta Trust Bldg., Atlanta, Ga., are architects.

Ind., Anderson—City, R. L. Creson, Clk., will receive bids until April 6th for drilling and equipping well, to furnish not less than 700 g.p.m. and vertical turbine pump with motor.

Kan., Kansas City—Air Reduction Sales Co., ft. of 56th St., Brooklyn, N. Y., has work under way on the construction of a plant for the manufacture of acetylene welding appliances and commercial gases for welding, including a 41 x 50 ft. gas house, 20 x 40 ft. oxygen storage house, 20 x 40 ft. carbide storage house, 18 x 30 ft. boiler room, 13 x 25 ft. generating room and 18 x 26 ft. office. Estimated cost $60,000.

Kan., Topeka—State plans the construction of a new steam boiler plant for Boy's Industrial School. Estimated cost $150,000. C. M. Routlidge is state architect.

Kan., Wichita—R. W. Ice Co., 821 East 21st St. will build a one and two story ice plant at 29th and Arkansas Sts., by day labor. Estimated cost $30,000. Private plans.

Ill., Shelbyville—City, will receive bids until March 31, for construction of 100,000 gal. tank on tower, one 700 g.p.m., and one 500 g.p.m. motor driven centrifugal pumps, foundations for pumping equipment, 4,200 ft. of electric transmission lines, etc. Estimated cost $40,000. W. A. Fuller Co., 1917 Railway Exchange, St. Louis, Mo., is engineer.

Me., Lewiston — Androscoggin Electric Co., plans the construction of a plant and line extensions. Estimated cost $200,000. Company engineer in charge.

Mass., Brookline (Boston P. O.)—Roosevelt, Inc., c/o Silverman, Brown & Heenan, 51 Cornhill, Boston, Archts., is having preliminary plans prepared for the construction of a 10-story apartment house on Beacon St. Estimated cost $2,000,000.

Mass., Lawrence—Dept. of Public Works, plans the installation of a boiler and pump, also filter basin. Morris Knowles, Inc., 507 Westinghouse Bldg., Pittsburgh, Pa., is engineer.

Mich., Kalamazoo — City, C. L. Miller City Mgr. is in the market for a 500 hp. boiler with equipment for burning pulverized fuel, for light and power plant.

Mo., Boonville—City will soon take bids for 2 motor-driven centrifugal pumps. Estimated cost $7,500.

Mo., Independence—City plans improvements to electric plant. Estimated cost to exceed $25,000. Black & Veatch, 701 Mutual Bldg., Kansas City, Mo.

Mo., Kansas City—R. T. Collins, 1600 Grand Ave., is having plans prepared for the construction of a 5-story hotel on Mill Creek Blvd. Estimated cost $850,000. G. B. Post, 1003 Pioneer Bldg., is architect.

Mo., St. Louis—City is having preliminary plans prepared for the construction of a hospital on Cottage, Kennerly, Goode and Whittier Sts. Estimated cost $1,250,000. L. R. Bowen and E. E. Christopher, 301 City Hall, are architects.

Mo., Kansas City—D. L. Kelley, Bonfils Bldg., plans the construction of a 7-story hotel at 46th and Main Sts. E. C. Farris, 3838 Main St., is architect.

Mo., St. Louis—St. Louis Ice Cream Co., 517 South Jefferson Ave., will build a 2-story ice cream factory at 4581-95 Page Blvd., by day labor. Estimated cost $100,000. Private plans.

Mo., St. Louis—Water Department plans the installation of four 500-hp. boilers and appurtenances for No. 2 boiler house at Bissells Point Water Works pumping station to replace four 350-hp. boilers. E. E. Wall, Comr., Third Floor, City Hall.

Mo., Steele—City voted $30,000 bonds for waterworks improvements including pumps, reservoir, mains, etc. A. C. Moore, 222 Industrial Bldg., Joplin, is engineer.

Mont., Troy—Great Northern Railway Co., Railroad Bldg., St. Paul, Minn., will soon award contract for the construction of a round house, 38 x 58-ft. power house, water tank, etc., here. Estimated cost $40,000. A. H. Hogeland, is chief engineer. T. D. McMahon is architect.

N. Y., Canandaigua—City, B. T. Cappon, Clk., plans to purchase and install one duplicate or auxiliary electric motor and pump; repairing present large electric motor and pump; and removing old water pumps and steam boilers at waterworks pumping station.

N. Y., Dannemora — Superintendent of State Prisons, Capitol, Albany, will build a 2 story cold storage building, as addition to existing buildings here. S. W. Jones, Capitol, Albany, is state architect.

N. Y., New York—New York Edison Co., 130 East 15th St., is having plans prepared for the construction of a 3-story, substation, on West 84th St. Estimated cost $150,000. W. Whitehill, 709 Sixth Ave., is architect.

N. Y., New York—Two Hundred Madison Ave. Corporation, c/o Warren & Wetmore, Archts., 16 East 47th St., awarded contract for the construction of a 25-story commercial building, including steam heating system, on Madison Ave. between 35th and 36th Sts., to D. P. Robinson & Co., Inc., 125 East 46th St.

N. Y., Perrysburg—City of Buffalo, J. H. Meahl, Commr., of Parks and Public Buildings, Room 13, City Hall, Buffalo, will soon award contract for the furnishing and installing turbo generator set with piping, feeders and switchboard, in power plant of J. N. Adams, hospital, here.

N. Y., Queens—State Hospital Commission, Capitol, Albany, will receive bids in June for the construction of a 3 story cold storage plant, at the Creedmoor Division of the Brooklyn State Hospital, here. S. W. Jones, Capitol, Albany, is state architect.

N. Y., Willard—State Hospital Commission, Albany, N. Y., will receive bids in June for underground water mains, pumping equipment, etc., for the Willard State Hospital, here. S. W. Jones, Capitol, Albany, is state architect.

N. C., Goldsboro—City, E. C. Robinson, Engr., is receiving bids for waterworks and sewer improvements, including engines, pumps, tanks, valves, etc. J. B. McCrearey Co., Inc., Atlanta Ga. is engineer.

O., Alliance—F. D. Miller, Dir. of Public Service, will receive bids until March 25th for two 350-hp. boilers for pumping station.

O., Cleveland Heights (Warrenville P. O.)—Jewish Orphans Home, c/o E. Joseph, 705 Union Trust Bldg., Cleveland, is having plans prepared for a group of buildings, including 14 cottages, administrative buildings, garage, power house, etc., on Fairmount Rd., near Belvoir Blvd. Estimated cost $1,500,000. Morris & Weinberg, 3608 Euclid Ave., Cleveland, are architects.

O., Mt. Union (Alliance P. O.)—McCaskey Register Co., Alliance, is having plans prepared for the construction of an office building, printing plant, 46 x 55 ft. boiler house, etc. Lockwood, Greene & Co., Hanna Bldg., Cleveland, is architect.

Okla., Ardmore—H. Rowe et al. Denton, Tex., will soon take bids for the construction of a 150 x 300 ft. and 75 x 150 ft. ice and cold storage plant, 25 tons per day initial capacity, here. Private plans.

Okla., Blackwell—City, W. H. Clarke, Commr. of Public Utilities, is in the market for a motor driven booster pump, of 1,000 g.p.m. capacity.

Okla., Chandler—City, D. D. Landsaw, Clk. will hold an election in April, to vote $35,000 bonds for waterworks improvements, including rebuilding of water plant, and installing new pumps, wells, mains, etc.

Okla., Lawton—City voted $180,000 bonds for filter plant, 3,000,000 gal. per day capacity, at Lake Lawton. Equipment will include motor-driven pumps. H. G. Olmsted, 2230 West 18th St., Oklahoma City, is engineer.

Okla., Ponca—City, J. W. Crow, Pur. Agt., is in the market for 2,500 g.p.m. motor-driven pump for waterworks, also new 1,500-hp. Diesel oil engine generator set, complete with accessories for municipal electric light plant.

Okla., Prague—City, H. W. Hartman, Mayor, will hold an election March 17th to vote $17,000 bonds for waterworks improvements including well, reservoir, extensions to distribution system, and air lift pumping equipment. Holway Engineering Co., Wight Bldg., Tulsa, is engineer.

Pa., Harrisburg—Bd. of Directors of the School District, D. D. Hammelbaugh, Secy. will receive bids until April 13th, for the construction of the William Penn high school, including power plant, two 200 hp. boilers, on Market St. Total estimated cost $1,000,000. E. Sibley, Harrisburg, is consulting architect.

R. I., Providence—Bd. of Hospital Commissioners, 150 Caton St., plans the construction of two hospital additions and nurses home. Estimated cost $850,000. Architect not announced.

Tenn., Nashville—Noel & Co. Ice and Cold Storage Co., 10th and Harrison Sts., awarded contract for the construction of a 4 unit cold storage plant including an 8-story cold storage building, freezing room, ice storage building, and office building, to the Gould Construction Co., Independent Life Bldg. Estimated cost $350,000.

Tenn., Selmer—Selmer Ice Co., J. M. Smith, Pres., plans the construction of a plant for manufacture of ice, including bottling plant and cold storage. Estimated cost $25,000.

Tex., Cooledge—J. R. Ogilvie, plans the construction of an ice plant. Estimated cost $45,000. Engineer not selected.

Tex., Donna—City voted $50,000 bonds for waterworks improvements including mains, pumping equipment, tank on tower, etc. Estimated cost $50,000. H. J. Wilson, San Juan, is engineer.

Tex., Fort Worth—E. P. Maddox & Co., c/o Crystal Ice Co., 301 East Magnolia St., awarded contract for the construction of an ice plant to supply Arlington Heights district, to C. T. Hodge & Co., Keene Bldg. Estimated cost $50,000. Owners will purchase machinery.

Tex., Houston—City, O. F. Holcombe, Mayor, will hold an election April 13th to vote $750,000 bonds for waterworks improvements, including two pumping plants and equipment, work on Scott St. plant, etc. J. C. McVea is city engineer.

Tex., Houston—Houston Oil Co., Scanlan Bldg., will soon take bids for 250 miles of steel pipe line, with pumping equipment, to run from Live Oak Fields to Houston. Estimated cost $7,000,000.

Tex., McKinney—McKinney Ice & Coal Co, plans the construction of an addition to ice plant to double present capacity. Estimated cost $45,000. Architect not selected.

Tex., Panhandle—City, C. E. Deahl, Mayor, plans an election to vote $35,000 bonds for improvements including installation of engine in power plant, etc.

Tex., Robert Lee—A. W. Puett plans the construction of an ice plant. Estimated cost $45,000. Engineer not selected.

Tex., Victoria—City c/o S. S. Sitterle, will receive bids until March 26th for 72 in horizontal tubular boilers, with tubes 18 ft. long, W. E. La Noue, Texas Bank Bldg., San Antonio, is engineer. City also plans an election soon to vote $65,000 bonds for electric light plant. $30,000 bonds voted at previous election.

Tex., Wellington—City, awarded contract for power plant extensions including 400-hp. Diesel oil engine generator set, one, 7 panel switchboard, cooling system, pumps, oil storage, etc. Estimated cost $50,000. V. V. Long & Co., Oklahoma City, is engineer.

Wash., Longview—Longview Memorial Hospital, Board of Directors, awarded contract for the construction of a 4-story hospital building, and power house, at Douglas St. and Orego Way, to J. E. Bonnell & Son, 827 North Tacoma St., Tacoma. Estimated cost $300,000.

Wash., Priest Rapids—Washington Irrigation and Development Co., holding company for the General Electric Co. of New York, announce favorable action by the Federal Power Commission, on their application for a license for development here. The plans include hydro-electric development at Priest Rapids, on the Columbia River, 200 miles east of Seattle, which will develop 400,000 hp.; dam 2½ miles long x 90 ft. high, to create the power reservoir, costing $28,000. Total estimated cost $100,000,000.

Wis., Pestigo—Wisconsin Public Service Co., 559 Marshall St., Milwaukee, J. P. Pullman, Gen. Mgr., plans the installation of an additional 500 k.w. turbine, in recently purchased hydro electric plant on the Pestigo River, 4 miles north of here. Mead & Seastone, State Journal Bldg., Madison, are engineers.

Wis., Milwaukee—Plankinton Packing Co., Muskego Ave. and Canal St., is having plans prepared for the construction of a 4-story cooler, etc., including refrigeration equipment, on Muskego Ave. Estimated cost $250,000. C. H. Kane, c/o Swift & Co., Union Stock Yards, Chicago, Ill., is architect and engineer.

Wis., Racine—Racine Hotel Co., L. Fowler, 1015 College Ave., is having new plans prepared for the construction of a hotel on Main St. Estimated cost $1,000,000. Fugard & Knapp, 219 East Superior St., Chicago, Ill., are architects.

Ont., Kingston—Monarch Battery Co., Ltd., 275 Ontario St., is in the market for two 15-kw. motor generator sets, or one 20- or 25-kw. and one 15-kw. generator set.

Ont., Ottawa—Hydro Electric Power Commission, Province of Ottawa, estimates for the fiscal year ending Oct. 31, 1925:

Niagara System—developments to cover expenditures on the Queenston-Chippawa No. 9 and 10, $2,000,000; betterments to existing developments at Niagara, Ontario Power Company and Electrical Development Company's plants, $150,000; engineering studies and investigations for No. 2 Queenston development, $100,000; improvements to Queenston-Chippawa development to canals and bridges $250,000, steam plants of initial capacity of 100,000 hp. including electrical generation, $5,000,000. Total $7,500,000.

Transformer Stations, to cover $800,000 for Queenston stations in increase transformer capacity for banks No. 9 and 10; for Toronto, $400,000; miscellaneous high voltage stations at Guelph, Preston, Stratford, Woodstock, Kent and Essex, $1,000,000; changes and additions in switching in several stations and low voltage stations, $300,000. Total $2,500,000.

High voltage transmission lines, including proposed line from London to Kent, $2,000,000; new low voltage lines, installation of larger conductors, etc., betterments to existing lines, $500,000. Total $2,500,000.

Extensions to existing rural lines, $500,000, items of capital expenditures not included in the above and additions to the same, $500,000. Total $13,500,000.

Georgian Bay System—developments. Muskoka for completion of increasing capacity of South Falls Development, $40,000; Muskosh, for development of Muskosh River, $550,000, betterments to present developments on Severn, Eugenia and Easdells Systems, $30,000. Total $620,000.

Betterments to transformer stations, $100,000; transmission lines $200,000; and completion of the Muskoka-Severn Tie Line, $30,000; rural lines, $80,000. Miscellaneous $100,000. Total $1,130,000.

St. Lawrence System—development at Morrisburg, $1,500,000. Miscellaneous transformer stations, $50,000; extensions to transmission line system, $100,000; rural lines, $50,000; miscellaneous improvements $20,000. Total $1,720,000.

Rideau System—General miscellaneous betterments to systems, lines, and transformer stations, $100,000.

Thunder Bay System—developments covering completion of No. 3 and 4 units, expenditures on No. 5 and 6 units at Cameron's Falls and completion of dam at Virgin's Falls, $1,700,000.

Transformer stations, increasing the capacity of Port Arthur and Fort William, $250,000.

Completing extensions of double circuit steel tower lines to Port Arthur and Fort William, $500,000. Miscellaneous, $100,000. Total $2,550,000.

Central Ontario System—Completion of Dam 8 and 9; Crow River Storage, $350,000; dams 4 and 5, $400,000; miscellaneous betterments to system, $100,000. Total $850,000. Extensions to transmission lines, $100,000; improvements to miscellaneous stations, $100,000; rural systems, $50,000; local systems including works and plants operated by the Commission, $200,000; miscellaneous items and betterments to the systems, $100,000. Total $1,400,000.

Nipissing System—Cox Chute and storage, at present developments, $100,000; transformer stations, $25,000; transmission lines, $25,000; local systems, $20,000. Miscellaneous, $10,000.

Ottawa System—developments on Ottawa River for delivery of power in this district, $750,000. Rural lines, $30,000.

Miscellaneous betterments to general works of commission, including service and administrative buildings, $500,000, plants, $50,000. Total expenditures, $550,000.